COTTON IN AUSTRALIA

RICHARD HARDING

COTTON IN AUSTRALIA

THE LARGE SHADED PORTION INDICATES WHERE COTTON MAY BE PRODUCED UNDER NATURAL RAINFALL. THE SMALL SHADED AREA IN THE SOUTH SHOWS WHERE COTTON MAY BE GROWN BY IRRIGATION FROM THE RIVER MURRAY AND ITS TRIBUTARIES.

COTTON IN AUSTRALIA

THE POSSIBILITIES AND THE LIMITATIONS OF AUSTRALIA AS A COTTON-GROWING COUNTRY

BY

RICHARD HARDING

Secretary to the British Cotton Delegation to Australia, 1922

Containing Numerous Illustrations and Graphs; together with Data relating to Australian Climate, Rainfall, Temperature, Soil Analyses and Cost of Production

LONGMANS GREEN AND CO.
39 PATERNOSTER ROW, LONDON, E.C. 4
NEW YORK, TORONTO
BOMBAY, CALCUTTA AND MADRAS
1924

Made in Great Britain

Dedicated to

THE

HON. CRAWFORD VAUGHAN

To whose Genius and Enthusiasm is mainly due the present Revival of Cotton-Growing in Australia

FOREWORD

One of the most pressing needs of the moment is a greater supply of raw cotton for the mills of Lancashire, for the American export is tending to diminish, and the diminution is by no means compensated as yet by production elsewhere. Under these circumstances a rapid extension is earnestly to be desired of the areas in the British Empire that produce cotton of medium staple, like that which makes the bulk of the world's supply. Australia has now shown that she can produce such cotton, and much interest and enthusiasm has been aroused. Mr. Harding's book is a useful key to the regions in Australia best suited to cotton and to the methods best suited to production, and indicates also the difficulties that have to be surmounted before Australia can take her place as one of the great cotton-growing countries of the world.

J. C. Willis.

Cambridge.
May 25, 1924.

PREFACE

This book is the result of eighteen months' investigations made in Australia, and is compiled from a careful study of local conditions made throughout various parts of the country. Its main object is to demonstrate the tremendous cotton-growing possibilities of that continent, and to prove by the pertinent statement of facts, or by comparisons with other countries, to what a vast extent great areas of Australia are adapted by climate and rainfall to commercial cotton production.

Australia is almost a virgin country in so far as the knowledge of cotton cultivation is concerned, as although a certain amount of cotton was produced there fifty years ago, no accurate records were kept relating to the behaviour of the plant. This lack of past experience as yet prohibits the making of definite assertions or the laying down of any hard and fast rules that growers should follow. It is only possible to offer tentative suggestions based on a study of climatic conditions and the experience of other countries with a somewhat similar climate ; for no matter how well substantiated such suggestions may be, they may yet prove necessary of modification when scientific research and a thorough study of Australian conditions place fuller information at our disposal.

Definite and accurate data may only be obtained from Government meteorological records ; and as the limiting factors of cotton growing throughout the rest of the world are to be found in rainfall, climate and soil, the same should apply with equal force to Australia ; hence, any deductions or opinions expressed herein as to Australian cotton possibilities have been primarily based on climatology.

Whilst the present writer is greatly indebted to those authors who have written on cotton in other countries, it does not necessarily follow that that which holds good in relation to cotton cultivation in one part of the world will prove equally applicable in another quarter of the globe. As the past history of cotton in Australia provides little or no authentic information that one may turn to for guidance, some allowance should be

made for the possibility of the plant in Australia developing characteristics or habits of growth differing slightly from those of plants of a similar variety in other parts of the world, but even so, such differences should only necessitate slight alterations in the methods of cultivation or minor deviations from the dates of planting suggested herein.

A comparison of climates shows that many parts of the States of Queensland and New South Wales are more suited to cotton than either the Nile Delta of Egypt or the United States of America. Cotton has given such great promise in these localities of Australia as fully to convince the writer that not only can that country with her white labour successfully compete in open markets, but that she is eventually destined to become one of the great cotton-producing countries of the world.

RICHARD HARDING.

January 1924.

CONTENTS

LIST OF ILLUSTRATIONS

COTTON IN AUSTRALIA

CHAPTER I

THE HISTORY, USES, AND GROWTHS OF COTTON

History—Uses—Chemical composition—Growths of cotton—Asiatic, Upland and Peruvian Groups—Main requirements of cotton—Different varieties —Cotton fibre or lint—Twist—Ideal cotton—Defects in cotton—Classification according to quality—World's varieties of cotton.

History.—The word *cotton* can be traced to the Arabic language, as the plant is indigenous to Arabia, and is called at the present day ' Utt'n ' in the Arabic tongue. It is an article of great antiquity ; over 2500 years ago it was converted into clothing, and was in common use in India long before the Christian era, reference being made to cotton as far back as 800 B.C. We are told that ' Ou-Ti Emperor of China possessed a robe of cotton about 500 B.C.,' and Nearchus, the Admiral of Alexander the Great, mentions having seen it growing along the shores of the Persian Gulf in 327 B.C. Its introduction into Europe occurred during the Mohammedan era about A.D. 650, and it was first manufactured into cloth in Mohammedan Spain at about that date. The first recorded shipment of cotton from Australia was from the port of Sydney in 1830.

The English cotton industry, unquestionably the greatest industry in the world, had its birth during the year 1697, when a cotton factory was established at Belper. Since then it has grown apace. James Hargreaves's invention of ' spinning jenny ' in 1767, and Richard Arkwright's invention of a spinning machine in 1769, did much to give the industry a start ; but it may be said that Samuel Crompton, by inventing his ' mule ' in 1779 (so called because of its being a cross between Arkwright's machine and Hargreaves's jenny), was directly responsible for putting the English cotton industry firmly on its feet. Lancashire's textile trade received great impetus in 1787 from the application of Watt's steam-engine, and the

invention of a power-loom by Dr. Edmund Cartwright, a clergyman. Some years elapsed, however, before the power-loom was first brought into profitable use at Glasgow in 1801. From then onwards the industry expanded very rapidly, but this expansion would have been impossible, had not an American, Eli Whitney, perfected his cotton saw-gin in 1793, thereby enabling more lint to be separated from the cotton seeds in one day of labour than could previously be done by one man in many months. The word 'gin' is an abbreviation of 'engine.'

In England alone at the present day over 3,000,000 people entirely depend on cotton for a means of livelihood, and some 10,000,000 are affected by it in one way or another.

Uses of Cotton.—Cotton is still essentially much the cheapest textile, and the greatest asset it possesses lies in the fact that it is almost the only fibre nature produces ready for immediate manufacture. Only a simple process, called ginning, is necessary to separate the fibre from the seed, and the fibre may then be straightway converted into yarn and cloth. Thus, there is a steady and never-failing demand for cotton goods, as this material still supplies the cheapest clothing for the world. Although the Great War has undoubtedly reduced the accumulated wealth of Europe, it has not seriously impoverished the great masses of the peoples of Asia and Africa whose purchasing power remains practically unaltered.

The lint or fibre produced by the cotton plant provides the world's inhabitants with five-sixths of their clothing, and it is estimated that out of the world's total population of 1,500,000,000, only 500,000,000 are completely clothed, 750,000,000 are only partially clothed, and 250,000,000 are not clothed at all. The bulk of humanity inhabits the tropical or semi-tropical zones, and what clothing they wear is composed almost entirely of cotton. Approximately half the clothing of those living in temperate zones is made from cotton, and it is only those who inhabit those or the arctic zones that have any real need of woollen clothing. The world's annual pre-war consumption of raw materials for converting into wearing apparel, or fabric of all kinds, amounted to :

5,400,000	tons of	cotton
1,250,000	,,	wool
500,000	,,	flax
24,000	,,	silk

There are few who realise how big a percentage of cotton is often used in the manufacture of 'woollen' and 'tweed' cloths used for suits, or how very frequently the so-called 'pure wool' goods contain more than a sprinkling of cotton in their composition.

During the last decade such strides have been made in cotton manufacture and the treatment of cotton yarn that it is now possible to make mercerised cotton fabrics of so fine a texture and of so glossy an appearance that they closely resemble the finest silk. In 1844 John Mercer discovered that when cotton is immersed in a strong solution of caustic soda it undergoes certain remarkable changes, the chief of these being the imparting of a silky lustre to the fibres. This has led to results of great commercial importance, and the process is now carried out on a very extensive scale under the name of 'mercerisation'; it is sometimes applied to the yarn and sometimes to the woven fabric. As cotton is cheaper than wool, great use is now being made of it to imitate woollen products: for instance, what is commonly known as flannelette is an ordinary cotton fabric made of coarse yarns. Velvets are also largely composed of cotton, and other cotton goods are baize, brocade, bombazine, dimity, drill, fustian, gauze, nankeen, gingham, print, rep and twill. Excellent sheeting is manufactured from a mixture of cotton and linen yarns, the goods so produced being known as 'union cloths.' As cotton possesses a very great degree of strength and pliability, it is now used in ever-increasing quantities in conjunction with rubber for the manufacture of motor tyres; Egyptian cotton, owing to its great strength, is specially adapted for this purpose.

Take, for instance, the clothes you wear. In all probability your shirt, tie, collar, the lining of your coat and waistcoat, will consist of pure cotton; while a large or small percentage of the materials which forms your suit, socks, underclothing, and handkerchief, will be of cotton. Glance round your own home; the blinds, the curtains, the chintzes that envelop the sofas or chairs, the covering of the cushions and the material with which they are filled, the sheets and the counterpane on the bed, together with the filling of the mattress, are in all probability composed of cotton in some shape or form. It even enters largely into the composition of the carpets and rugs for the floors or stairs; also of bath towels, mops, and medicated dressings and cotton wool. No particle is wasted of the wonderful harvest yielded by the cotton plant to its

grower, for each and every atom that goes to form part of the fibre or seed is fully utilised. There seems to be no end to the uses to which cotton can be employed and every year increases the list.

The consumption of cotton must increase with the expansion of civilisation, for the first demand of the half-nude or semi-civilised savage of Asia or Africa is a loin cloth for himself and some kind of gown for his womenfolk. Every mile of new railway that penetrates these countries brings with it some form of civilisation and facilitates the delivery of cheap cotton cloth, the first article sought for by the natives. Railway communication also provides a channel whereby those natives may dispose of their produce to the outside world and this in its turn results in increasing their purchasing capacity.

Commerce and science are for ever seeking new means of economising labour in the process of manufacture, and each new invention that expedites the conversion of raw cotton into cloth also lessens the manufacturing cost and lowers the price of the finished article, thereby increasing the demand for all kinds of cotton goods. One hundred and fifty years ago cotton was scarcely known or used by civilisation: to-day it forms the world's most essential textile, and it is impossible to foretell the future or prophecy where and when the demand for cotton and cotton goods will cease.

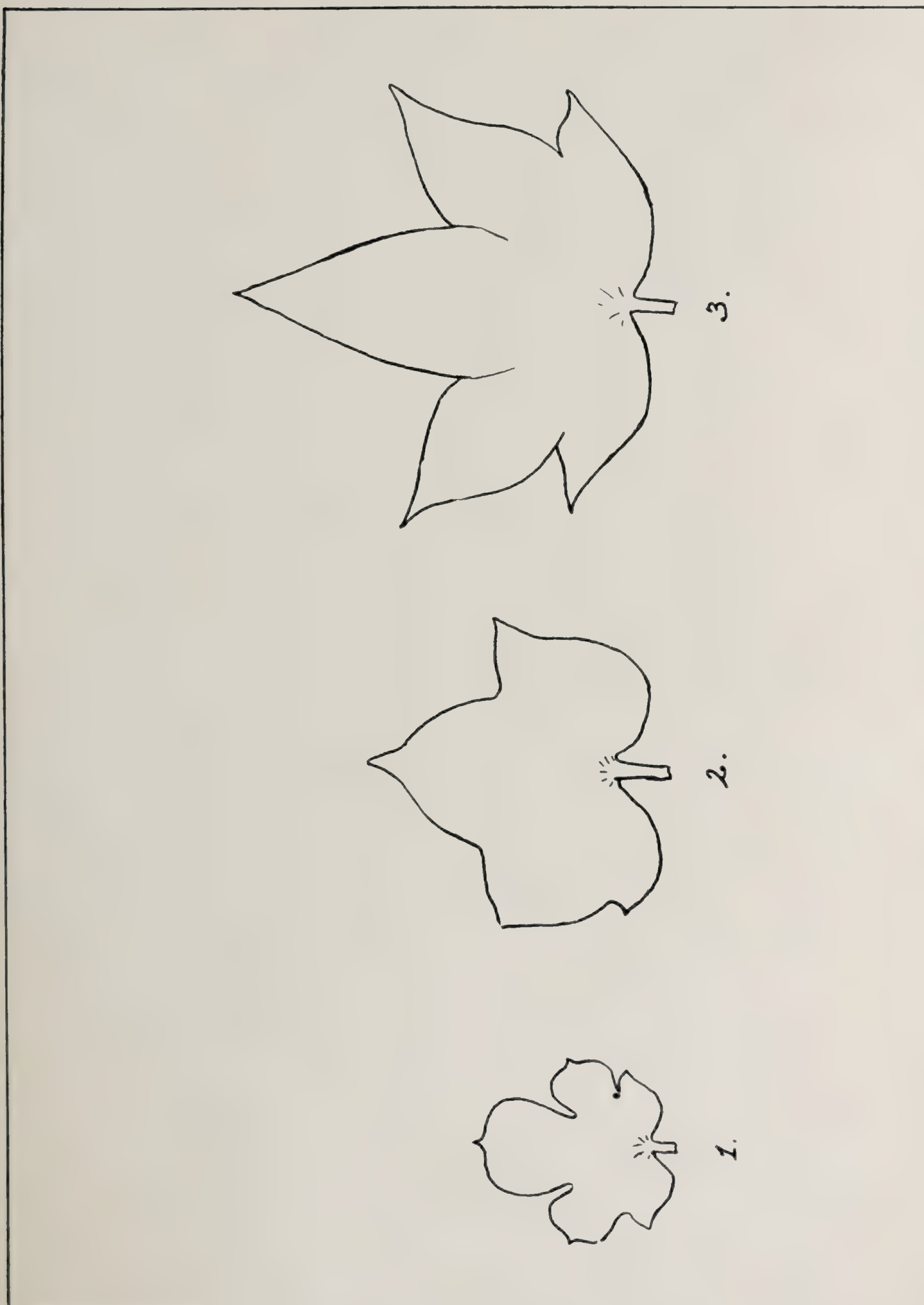
Chemical Composition.—The chemical composition of cotton mainly consists of about 90 per cent. of a comparatively pure form of cellulose, 7 to 8 per cent. of water, 1 per cent. of mineral water, 0·6 per cent. of nitrogenous substances, and 0·4 per cent. of wax and oil. The wax forms a very thin layer over the surface of the fibre and renders it more or less incapable of readily absorbing water. The high cellulose content of cotton has largely resulted in it being used as a base for high explosives, gun-cotton and cordite being but two examples.

Growths of Cotton.—Cotton belongs to the order of Malvaceae, its generic name being Gossypium, and it may be divided into three main groups, namely:

Asiatic Group,
Upland Group,
Peruvian Group.

Asiatic Group.—*Gossypium herbaceum* and *Gossypium arboreum.* These comprise the bulk of the cultivated Indian cottons, the extinct mediæval cotton of Northern Egypt,

Diagrammatic Sketch of Cotton Leaves



1. Asiatic; 2. Upland; 3. Peruvian.

Illustrating the Main Differences in Size and Form between the Three Principal Groups of Cotton.

Levant cottons, certain indigenous African tree cottons (*Gossypium arboreum*), Russian, Chinese, Turkestan and Persian cottons.

Upland Group.—*Gossypium hirsutum ;* so called because of the hairy character of the plants ; leaves, stems, branches, and, especially, seeds all having short hairs upon them.[1] It is considered by some authorities to be a sub-variety of *Gossypium barbadense,* but as the plant has certain well-defined characteristics these possibly entitle it to be considered as a distinct type ; the more so that competent authorities have asserted that the original habitat of this particular cotton was Mexico. Under this heading may be classed American Uplands, Egyptian Hindi Weed Cotton, and Cambodia.

Peruvian Group.—*Gossypium peruvianum,* so named because Peru is credited with being the original habitat of this cotton, and also considered by some authorities to be synonymous with *Gossypium barbadense,* a name originally derived from the island of Barbados. This group embraces Sea Island, Peruvian and Egyptian cottons.

Main Requirements of Cotton.—Cotton is a sub-tropical or tropical plant, its area of growth being approximately limited to those regions lying between the 40° north and the 35° south latitude. Cotton cultivation in the United States is practically confined between the 31° and 36° parallels of N. latitude. Egypt is sub-tropical. In India cotton is found in every latitude from 30° N. to 8° N. In Brazil it is found growing from the equator to 25° S. latitude. Although the plant is native to almost all tropical or semi-tropical countries, it yet seems certain that whatever may be the possibilities of its scientific development, the controlling factors in each particular country will always be found in the climate and the soil. Cotton will not withstand frost, and there must, therefore, be a sufficient period between the spring and autumn frosts to allow of the plant reaching maturity. Briefly, one must have 200 days without frosts. There must also be sufficient rain—about 20 inches—to enable the plant to grow and develop, and there must be sufficient fine weather during harvest time to permit of the cotton being picked before it is spoilt by rain or wind. Depth of soil is essential ; the ideal soil is a sandy loam at least six feet in depth, as the tap root penetrates in a downward direction for this distance during a normal season, under

[1] It is by the ' fuzz ' or woolliness on the seeds that this variety is best distinguished from the succeeding one.

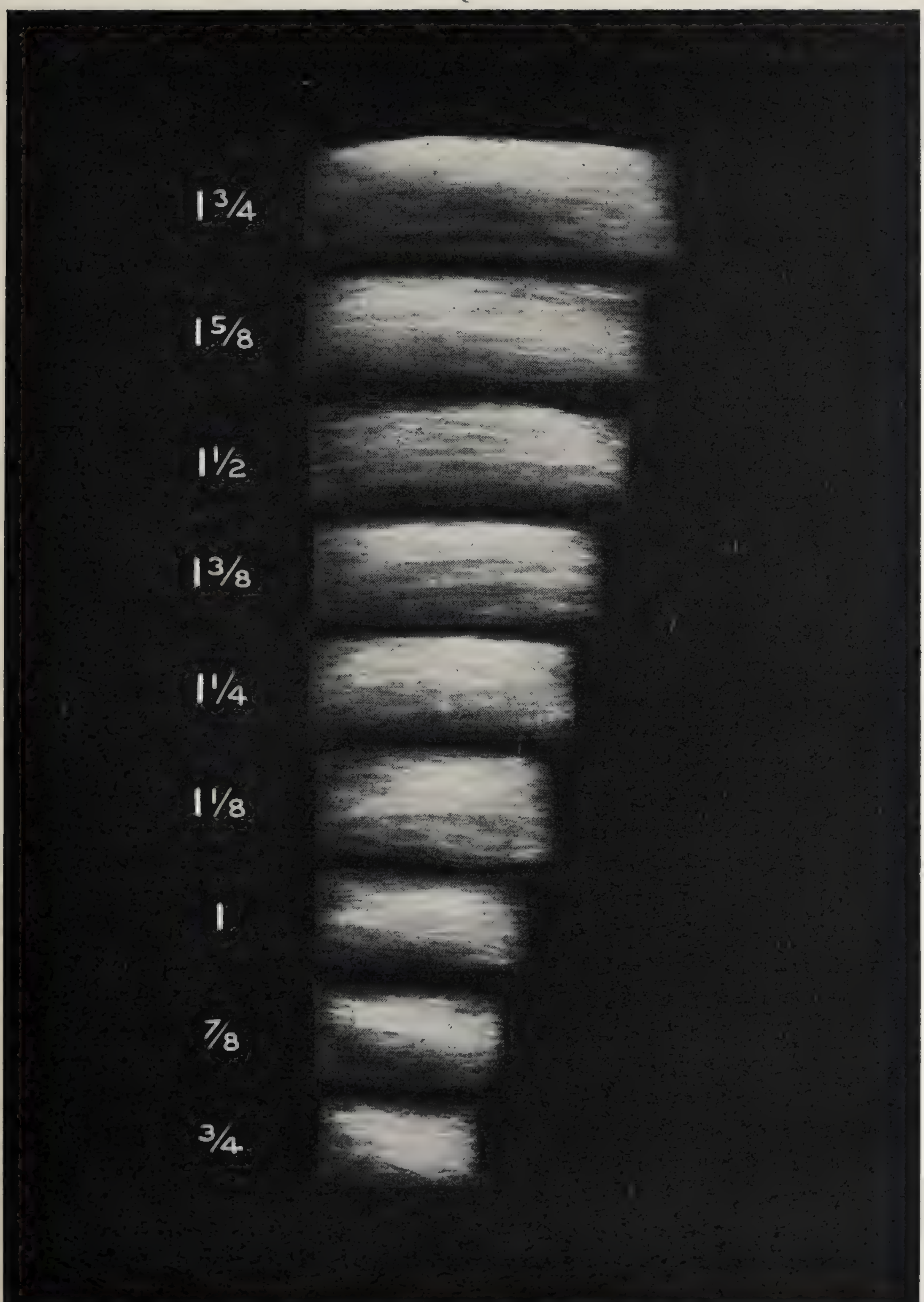
A Sturdy Upland Cotton Plant during its later Flowering Stage, Grown at Penrith, near Sydney, New South Wales.

average conditions. Owing to the comparatively porous nature of sandy loams this type of soil presents no obstruction and has no suffocating effect on the root system of the plant, which is thus allowed free scope for normal development. The surface of the ground can be easily worked up into a fine tilth, and thus a large amount of moisture may be conserved in the ground to sustain the plant throughout dry seasons, as loams are less liable to crack than heavy clay soils. Water-logging of the soil is fatal, as the plant is killed through water-suffocation of its root system. The period of growth differs for different varieties of cotton, and is generally shorter for the coarser and shorter stapled cottons, such as American Uplands, than for finer varieties such as Egyptian. The length of time from sowing to the commencement of harvesting is 107 days in India, 122 days in the United States, 185 days in Egypt and 200 days with Sea Island cottons. In every case some two or three months of picking must be added to the foregoing figures.

Different Varieties.—Sir George Watt, in his book, 'Wild and Cultivated Cotton Plants of the World,' describes forty-two species, and considerable ambiguity has resulted from the indiscriminate manner in which botanical names have been applied. It frequently happens that a particular species is given different names by different botanists. As cotton readily undergoes hybridisation and freely responds to altered conditions of cultivation, soil, climate and environment, it is only natural that confusion should arise in the determination of the botanical identity of groups, rendering it a difficult matter to ascertain accurately which are the true species and which are only varieties.

Cotton Fibre or Lint.—The unripe fibre of cotton is composed of a single hollow cell in the form of a long cylinder or tube, without transverse partitions. The base is attached to the seed, but the greatest diameter of the fibre is only attained at a point one-third of its length from the seed.

Twist.—Until the boll opens the fibres retain their true cylindrical form, but when once a boll has burst the walls of the ripe fibres collapse and the lint assumes a ribbon-like form, somewhat opaque and with slightly thickened, rounded edges. Up to this period the fibres have been true cylinders devoid of twist or convolutions, but with the collapse or flattening of the walls as the fibres dry, minute pits set obliquely



Illustrating the Official Cotton Standards of the United States of America. Representing the Respective Lengths of the 'Pulled' Staple as taken from the Original Type Bale.

in the cell walls also contract and close; it is the closure of these pits that imparts a spiral form to the lint.

The convolutions of the fibre do not always run in the same direction, the direction reverses at intervals; the cause of this reversal of twist is not clear, and one can only conjecture that it arises through some check in the growth of the plant. The number of convolutions in a given length of lint is very variable, but is increased by good cultivation of the plant. The finer the diameter of the fibre, the greater the number of twists, hence they are most numerous in West Indian Sea Island cotton, which is the finest variety yet produced.

The surface of the lint is smooth, and it would therefore be difficult to spin were it not for the fact that it possesses this peculiar characteristic twist. This imparts a certain 'roughness' to the fibres and enables them to exert a grip on one another when spun into yarn. It therefore follows that the pitch of the convolutions is of the greatest importance, for if the pitch is too low the fibres will not interlock properly, and if too high they will be liable to kink in preparation for spinning.

Ideal Cotton.—The ideal cotton may be defined as that which possess fibres of uniform length, strength and diameter, all having a similar number of convolutions per fibre in the same direction, spaced at equal intervals from end to end; it must also be free from foreign matter, such as particles of leaf, broken seeds and stained or discoloured fibres. Such a cotton would produce no waste, and the fibre would perfectly interlock in spinning so as to produce the maximum resistance against slip for whatever twist it received.

Defects in Cotton.—A purchaser of raw cotton closely examines it for any of the following bad points. Variation in length, strength, or diameter; harsh, rough, or intractable fibres; bad or uneven colour; insufficient bloom or lustre; for particles of leaf, dirt, shell, seeds, small pieces of broken seeds with fibre attached to them (called 'bearded motes'); immature or dead fibres, neps or knotted fibres; and also for fibres with few convolutions. All these defects have a deteriorating effect upon the value of the cotton, as they increase the percentage of waste that has to be discarded in the spinning process.

Classification of Cotton according to Quality.—1. West Indian Sea Island; grown on the islands bordering the Carolina coast of America and the West Indian Islands.

2. Georgia and Florida Sea Island, Sakellaridis, Best Brown and Abbassi (the last three are Egyptian varieties).

3. Afifi, Achmouni (both Egyptian), American Long Staple Upland, Peruvian and the best West African.

4. Australian, ordinary American Upland, Brazilian, West African, Russian, Levant and the best Indian.

5. Indian, Native Russian and Chinese.

World's Varieties of Cotton.—The following list gives a brief summary of the principal cottons of the world, their lengths of staple, colour, the counts of yarn they will spin, and their chief characteristics :

Variety.	Average Length.	Colour.	Counts up to.	Remarks.
West Indian Sea Island . .	2	Cream . .	300	Very fine, silky and regular.
Egyptian :				
Sakellaridis .	$1\frac{1}{2}$	Rich cream .	180	Silky, fine and soft.
Best Brown .	$1\frac{3}{8}$	Deep brown .	160	Fine, strong and regular.
Abbassi . .	$1\frac{3}{8}$	White . .	130	Silky.
Achmouni .	$1\frac{1}{8}$	Muddy brown	60	Very strong, but dirty.
Brazilian :				
Pernams, etc. .	$1\frac{1}{8}$	Dull white .	60	Harsh.
Ceara, etc. .	1	Dull white .	60	Harsh.
Peruvian :				
Rough . .	$1\frac{1}{4}$	Cream } for mixing		Harsh and wiry.
Mod. Rough .	$1\frac{1}{4}$	Cream } with wool		Harsh.
Smooth . .	$1\frac{1}{8}$	White . .	60	Soft, similar to American.
Sea Islands .	$1\frac{3}{8}$	Variable .	120	Silky, but irregular.
Australian . .	$1\frac{1}{8}$	White . .	60	Similar to American, but stronger and finer.
American :				
Orleans . .	$1\frac{1}{8}$	White . .	60	Clean, soft and strong.
Texas . .	1	White . .	50	Clean and strong.
Uplands . .	1	White . .	50	Softest of Americans.
Mobile . .	$\frac{7}{8}$	White . .	50	Dirtier and weaker than others.
West African .	1	White . .	50	Similar to American.
Indian :				
Surtee, Broach, etc. . .	$\frac{7}{8}$	Light brown	20	Clean and strong.
Scinde . .	$\frac{5}{8}$	Dull white .	10	Poor and dirty.
Bengal . .	$\frac{5}{8}$	Light brown	10	Dirty and harsh.
Tinnivelly .	$\frac{7}{8}$	White . .	20	Best of Indians.
Madras, Western	$\frac{3}{4}$	Light brown	20	Fair class.
China . .	$\frac{3}{4}$	Dull white .	20	Rather harsh.
Smyrna . .	$\frac{7}{8}$	Dull white .	20	Rather harsh.

CHAPTER II

THE WORLD'S COTTON SHORTAGE

Need of the British Empire producing cotton—The Boll Weevil in America—Decrease in the world's production—Need of expansion in cotton production — Egypt—Soudan—Uganda—Nigeria—Mesopotamia—British West Indies—Cotton production within the British Empire—Statistics—South America—Future prospects—Australia.

Need of the British Empire Producing Cotton.—Since 1914 there has been a steady decline in the quantity of cotton grown, and the world is to-day faced with the possibility of a grave shortage.

For many years the economic and commercial unsoundness of the British cotton industry, due to its utter dependence on foreign countries for its supply of raw material, has been fully realised by many of those directly interested in the cotton trade. Efforts have been made to encourage cotton-growing within the Empire in order to make the British industry self-supporting and independent of outside supplies, with which war or revolution might at any moment interfere. The British nation is primarily interested in the production of the finer and higher priced varieties of cotton so particularly suited to the requirements of Lancashire, and for this reason little or no account has been taken in the following pages of the cottons of India or China, as these are of too poor a quality to be of much use to England.

Although there are many who may have vaguely felt the danger of a cotton shortage, it is perhaps only quite recently that Lancashire as a whole has forcibly realised the actual seriousness of the situation regarding the world's cotton supply, and the danger of a recurrence of a cotton famine similar to that which existed during the American Civil War.

The Boll Weevil in America.—The main cause for this shortage lies in the fact that America is unable to increase her cotton production owing to the grave havoc caused by the boll weevil, a pest that originally entered Texas, U.S.A., in

1892, from Mexico. This insect has a twofold effect upon cotton production: firstly, it has so reduced the yield per acre over practically the whole American cotton belt, that the cultivation of cotton is now so unproductive in many areas that it is either impossible or is less profitable than other crops. Secondly, owing to the diminished yield and cash return, there is every probability that the acreage in future years will be reduced and the land devoted to other crops. According to reliable figures, the damage caused by this pest is estimated at:—

6·69	per cent.	of the	American crop	in	1913
13·36	,,	,,	,,	,,	1916
19·95	,,	,,	,,	,,	1920
30·98	,,	,,	,,	,,	1921 [1]
39·00	,,	,,	,,	,,	1922 [1]

Although the best brains of America have been endeavouring for some years past to discover a remedy for the boll weevil, no practical commercial antidote has yet been found, and unless some preventive is quickly discovered, it seems certain that the day is not so far distant when America will be unable to produce enough cotton for her own needs, and instead of being a cotton exporting country she will be compelled to import cotton to meet her ever-growing requirements.

How serious a menace to the cotton industry of the world this small insect is may be emphasised by quoting from 'Weather, Crops and Markets,' an official weekly publication issued by the United States Department of Agriculture. In the issue of August 26, 1922, the following appears:—

'The production of 6,277,000 bales of cotton, in addition to the seed that would have been ginned from that amount, was prevented by the boll weevil in 1921, according to the computations made by the United States Department of Agriculture, from estimates furnished by many thousand crop reporters. This damage to the potential 1921 crop exceeded that of any former year, notwithstanding the relatively small acreage planted to cotton that year. In fact, the boll weevil damage in 1921 represented an increase of 37 per cent. over the damage to the 1920 crop, when the boll weevil prevented the production of 4,595,000 bales.'

[1] It should be stated, however, that some authorities in America hold that the damage indicated by the figures for these two years has not been due to the boll weevil solely.

For many years there has been a steady decrease in the average American yield per acre, and this may be directly attributed to Boll weevil damage or causes arising therefrom :

Season	1912–13 average American yield of seed cotton per acre				600	lb.
,,	1915–16	,,	,,	,,	530	,,
,,	1920–21	,,	,,	,,	480	,,
,,	1921–22	,,	,,	,,	372	,,

The figures for 1922–23 are not as yet available, but it does not appear probable that the yield per acre will exceed that of the 1920–21 season.

The European war has had the effect of universally raising American wages ; the boll weevil has caused an increase in the cost of producing cotton ; the combination of these two factors has greatly increased the average cost of production per lb. of lint throughout the American cotton belt, and it is now computed to amount to 24·25 cents per lb., or just over 12 pence. In 1922 the lowest average cost was at Alabama, 17 cents, and at Georgia, 27 cents.

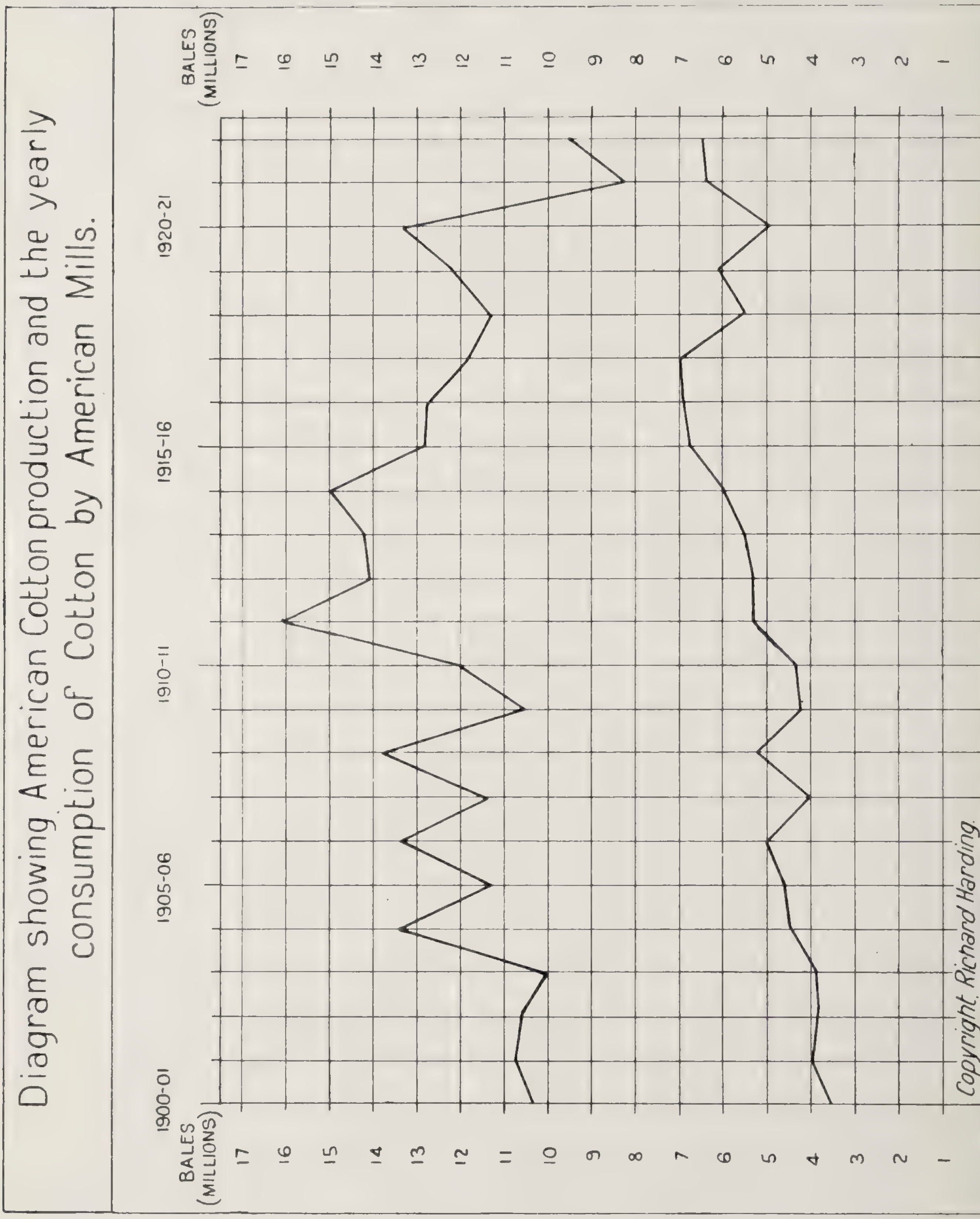
In the United States at the present time, cotton growing has developed into a race between the maturing of sufficient bolls to form a commercial crop and the multiplication of the boll weevil ; for now there are practically only some 24 or 25 weeks available between sowing time and the ripening of the last bolls. Thus, that country is now confined to growing those cottons that will produce a paying crop in five to six weeks less time than is available in Egypt ; whereas, previous to the advent of the boll weevil, America had at least another month before the first winter frost terminated the growth of the plants. This pest inflicts a special injury to the longer staples, and consequently, where the weevil is prevalent the tendency is to plant only early-maturing cottons that are short in staple and generally unsuitable for fine counts. Coarse or short-stapled cotton will only spin coarse yarns, and as these can be spun more rapidly than finer counts, the mills annually consume a greater weight of cotton. This fact, taken in conjunction with the damage caused by the boll weevil is mainly responsible for the disproportionate increase in America's consumption of her home-grown cotton. The bald facts, in relation to American cotton production and American home consumption are shown by the graph on p. 16.

During the period 1901–5, America consumed 36 per cent. and exported 64 per cent. of her crop. To-day, the position

A Good Specimen of a fully developed Flower, American Upland Variety. This is followed by a green boll that eventually bursts and exposes the ripe cotton.

is reversed and American mills consume approximately 65 per cent., leaving only 35 per cent. available for export to foreign mills.

Decrease in the World's Production.—Previous to the war it was estimated that if the world's cotton production was to keep pace with consumption, the quantity grown must show



THE UPPER LINE REPRESENTS THE AMERICAN CROP, THE LOWER LINE REPRESENTS THE AMOUNT OF COTTON THE AMERICAN MILLS CONSUME ANNUALLY.

an annual increase of 750,000 bales. Even though it may have been impossible for this large increase in production to materialise, some augmentation should have occurred, and the position would not now be so serious if only cotton production

had remained at its pre-war figure. During 1914 the world's total cotton production reached a record figure of 26,022,000 bales of approximately 500 lb. each, of which amount America supplied 62·00 per cent., but since then there has been a steady decrease, both in America's percentage of the total and in the world's supply. In 1921 the world's crop amounted to 15,593,000 bales, of which America supplied 53·48 per cent. This appears to indicate a decrease in the world's total production of over 10,000,000 bales between 1914 and 1921. These figures, however, are rather misleading and do not present a fair indication of the mean decrease, as the 1914 crop was a record and that of 1921 was phenomenally subnormal, the Indian crop being the smallest for several years and the American crop the lowest recorded since 1895–96. After making due allowance for extremes in either direction, the world's production during the year 1922 shows an approximate decrease of 6,000,000 bales as compared with the period 1911–14. A cotton famine has so far only been averted by the Great War, by the consequent chaos and disorganisation of trade, and by the increased prices of both the raw and the finished products. Even the five years that have elapsed since the armistice have done little to right matters. It is true that during the cotton boom of 1919 to 1920, when the world was restocking its depleted wardrobe, prices of raw cotton and cotton goods rose to undreamed-of heights, but they fell with equally startling suddenness when the universal slump set in. Since that date those who have been compelled to purchase have, owing to scarcity of cash, bought the cheapest goods that would suit their most urgent requirements. The world has not yet recovered from its insolvent condition. The great majority of English mills are not working full time. The Russian mills, which in pre-war days consumed approximately 3,000,000 bales annually, are to-day either destroyed or totally closed down. The Eastern markets of Turkey, Russia, Asia Minor, India and China are very unsettled, and trade there is bad, while the countries that used to form Austria, with their estimated population of about 50,000,000, are too bankrupt to purchase from their European neighbours or from Great Britain. Yet, despite universal bad trade and unsettled conditions, the world's actual consumption of cotton in 1921–22 exceeded the quantity grown, the balance being provided from the 'carry over' of previous years.

Although it is undoubtedly true that the Great War has

reduced the accumulated wealth of Europe, and has made a lower standard of living necessary for many millions of people, it seems hard to believe that it has altered the fundamental factors governing the consumption of cotton. Cotton still forms the cheapest clothing in the world. With the exception of Russia, the great masses of the peoples of Asia, India and Africa have not been seriously impoverished or handicapped by the war: their purchasing power remains unaltered even though the quantity they are capable of buying may be reduced by enhanced prices. Notwithstanding the number of people who have perished owing to war and pestilence since 1915, the world's population to-day is greater than it was then. Food is humanity's first essential: clothing is its second. Five-sixths of this clothing is made from cotton. Where is this raw material to come from?

There are signs of a slow, yet steady, trade improvement; the world is gradually settling down. Any appreciable improvement in trade will result in the present sub-normal production of cotton being felt, while anything resembling a return to pre-war conditions must result in the position becoming acute.

Lancashire lives—one may almost say—entirely by the manufacture of raw cotton into yarn and cloth; thus, an adequate supply of this commodity forms the breath of life to her population. Her shrewd and far-sighted merchants long ago foresaw the present deficiency in the world's supply, and fully realised how economically unsound is their position, since they wholly rely for their livelihood on raw material over which they can have no direct control, as the bulk of it is produced outside the Empire. It was their desire to rectify this defect, and to guard against a future cotton shortage, that some years ago gave birth to the Empire Cotton Growing Committee, whose main object is to foster and encourage cotton growing within the British Empire. The spinners of Lancashire and the British Government foresaw that such an organisation must have ample funds if any appreciable result were to be achieved. The Government accordingly made a grant of £1,000,000, and 90 per cent. of the spinners agreed to a voluntary levy of 6d. on every 500 lb. bale that was imported into the United Kingdom. This levy has since been made law, and gives to the Empire Cotton Growing Committee a yearly income of approximately £100,000, with which to encourage cotton growing in British dependencies, either by rendering financial assistance or by paying the salaries of expert instruc-

tors. Although they have done much, they have been utterly unable to make good the shortage ; Lancashire and the world are still faced with the problem of securing adequate supplies.

America also is fully alive to the danger of the cotton situation, but it might be thought that she would be antagonistic to the growing of cotton in new countries, since any increase in the price of raw cotton must benefit America, who produces just over half the world's crop. As, however, America appears to be unable to increase the size of her crop, she realises that the day may come when she will be compelled to import large quantities of cotton if her mills are to be kept in operation, and instead of being antagonistic, she welcomes and encourages cotton cultivation in new fields. As far as Australia is concerned, it must here be recorded that the United States Department of Agriculture has rendered every assistance it could and has willingly supplied all information asked for.

Although it may be true that the encouraging of cotton growing within the British Empire may have originated from selfish motives on the part of Lancashire, it cannot but have a very beneficial effect on the Empire as a whole. It is solely through the cultivation of cotton that Egypt and the Soudan have been made rich instead of bankrupt; the West Indian Sea Islands, St. Vincent, Montserrat, the Uganda district of Africa, have all been raised from poverty to comfort by the growing of cotton, and the industry must also benefit any other country that can make it a commercial success. The foregoing does not take into account the increased employment and prosperity which must also result to shipping companies, banks, or others who have to finance, transport, or handle the crop.

Lancashire, by reason of her favourable climatic conditions, her mechanical ingenuity and the accumulated experience of her operatives, is admirably suited to the spinning of fine counts and the weaving of delicate fabrics. In this respect she stands supreme, proof being provided by the fact that, although the number of spindles has appreciably increased during recent years, the weight of cotton imported into Lancashire shows little augmentation. Some Lancashire mills are 'fine,' others we call 'coarse,' but with few exceptions they are all engaged in the spinning of what are elsewhere known as fine counts. This industry is of immense importance to Great Britain on account of the great number of people for whom it provides employment, and for the value of the goods exported, which in 1913 amounted to £125,000,000, consisting

entirely of cotton yarns, piece goods or other cotton materials. An industry of this magnitude is worthy of care and attention, and it would pay the Empire to specialise on the finer varieties of cotton that are so essential to our own requirements.

The problem of cotton growing within the Empire resolves itself into the question, first of all, of whether we can grow sufficient of the very fine Sea Island types for our own needs ; secondly, whether we can steadily and progressively increase the supply of cotton of the Egyptian type ; thirdly, and most important of all, whether the Empire can within a reasonable number of years be brought to produce some two or three million bales of cotton equal to, or finer, in quality and spinning utility than the great staple crop of America.

Need for Expansion in Cotton Production.—Expansion in cotton growing must be rapid ; where can one look for help ? What countries possess the requisite climate and areas of agricultural land that, after making good this deficit of 6,000,000 bales in the world's supply, will still have sufficient in reserve to meet future requirements as the demand arises ? Let us take each country in turn and consider its past, present and future possibilities.

Egypt.—Egypt's maximum cotton production was reached during 1913. In the period 1911 to 1915 she produced an average crop of 1,350,800 bales of 500 lb. each. Since that date her production has been steadily decreasing, and for the present season, 1922–23, the Egyptian crop is estimated at barely 1,000,000 bales. The area available for cotton growing in Egypt is necessarily limited, and even though it may still be possible to bring her annual area under cotton up to 2,000,000 acres, this figure cannot well be exceeded, unless the present law prohibiting cultivators from putting more than one-third of their land under cotton is repealed. Should this occur, or the Egyptian Government permit the natives to plant whatever area they desire with cotton, the output would undoubtedly show a very considerable increase for the two or three years directly following the cessation of control, but after this period there would be a rapid decrease in yield and quality, due to impoverishment of the soil, and the final production would show little or no increase over its present figure. In view of past experience in that country, the steady decrease in yield, and the fact that the best lands are already under cultivation, it would appear that the actual weight of cotton produced cannot be greatly augmented, as any new areas

brought under cultivation will consist of comparatively poor lands, giving a lower yield and a poorer quality of cotton.

A very important point when considering future cotton possibilities in Egypt lies in the fact that she has recently obtained Home Rule. The position which she now holds of producing the finest quality cotton in the world (excepting the small quantity produced by the West Indies) is largely due to British enterprise and initiative, to the large irrigation schemes carried out during the British occupation, to the control exercised over the cultivation and water supply, and to the steps taken to combat insect pests. Now that Egypt controls her own internal affairs it is but natural for her to appoint Egyptians to responsible and administrative posts previously held by white men who—almost without exception—were above bribery or corruption. There are few Britishers who care to work under coloured races, and many of those who hold responsible positions in the Egyptian departments of Agriculture, Irrigation and Finance are now tentatively seeking for positions in other countries. Very many of those who have had experience of Egyptian conditions, and who should therefore be qualified to pass an opinion, have grave doubts whether, when left to themselves, the natives will be capable of efficiently governing their own country. It is feared that there may be a general backsliding into the old slip-shod methods, that a laxity of control will be exercised over vital agricultural matters and seed breeding, that the system of water rotations will not, in fact, be adhered to, and that the highest bidder will obtain unlimited water to the detriment of others situated at the tail-ends of canals ; should this prove to be the case, it will not benefit the Egyptian cotton crop either in quantity or quality. There is a great similarity between all Eastern races, and most people will admit that anything resembling Turkish regime, or governmental methods, leaves much to be desired.

The falling off that has already taken place in Egyptian production may be attributed to three causes :

(1) Water-logging of the soil, due to over-irrigation and insufficient drainage,

(2) The boll worm and pink worm, which together account for some 10 to 15 per cent. of the potential crop,

(3) Mixture of seed by seed merchants and ginning factories, resulting in cross-fertilisation and the production of hybrids that give a lower yield than true strain plants.

It therefore seems probable that little or no further expansion in output can be expected from that country.

Soudan.—It has been proved that the Soudan can produce cotton of very nearly as good quality as the finest grown in Egypt, but the quantity produced is as yet small: the crop of 1921 amounted to approximately 30,000 bales, that of 1922 showed an appreciable increase, namely, 40,000 bales. The Soudan comprises an area of 1,014,000 square miles with an estimated population of 3,400,000; consequently its cotton crop is bound to assume larger proportions, as the country has both the area and the population requisite for meeting future expansion; yet any immediate big augmentation in the crop is hampered by lack of railways. This in itself should not prove a permanent detriment, as the bulk of the country is level and presents no obstacle to rapid railway construction; but as the cotton will always have a long journey to the seacoast this must very largely add to the cost of handling the crop. The greatest handicap to any rapid increase in the Soudanese crop is the fact that the majority of it is grown under irrigation, and existing works are insufficient to meet any great expansion in cultivation. It has been estimated that the capital outlay necessary to bring large new areas of land under cotton cultivation will amount to about £10,000,000, and as some years must elapse before these irrigation schemes could be completed, no immediate or large increase in output can be expected from the Soudan.

Uganda.—Area, 110,300 square miles; population, about 3,000,000. It would seem as if this district held greater promise of rapid extension in cotton growing than any other in Africa. The climate and soil are eminently suitable and, as all the cotton is grown by natural rainfall, the need for the construction of irrigation works and the delay attendant thereto do not arise. The quality of the cotton produced is satisfactory, being slightly superior to American Upland, and is therefore well suited to Lancashire's requirements. The industry in Uganda has shown a rapid increase: the 1918 production was 23,000 bales of 400 lb., that of 1921 being 81,300 bales. Further rapid expansion is looked for, and it would appear possible that the crop may reach 1,000,000 bales per annum. Here again, however, distance from the sea must considerably add to the cost of marketing.

Nigeria.—Area, 336,000 square miles; estimated population, 17,000,000. The northern and southern provinces of this

State, particularly Northern Nigeria, have great possibilities, and figures for recent years show a big increase in production. The 1918 crop amounted to 6200 bales of 400 lb. each, which during 1921 had increased to 31,500 bales. Compared with Uganda and the Soudan Nigeria is very advantageously situated on the Atlantic seaboard, and the sea freight from the coast to Europe is considerably less than that of Uganda cotton, which has to come round the Cape of Good Hope, or the Soudanese crop, which has to pay heavy canal dues. In addition, the Nigerian population of 17,000,000 makes rapid expansion possible in that country, and it seems reasonable to suppose that during the next year or two the Nigerian crop may easily amount to 100,000 bales, and finally perhaps exceed even 1,000,000 bales per annum.

The production throughout other parts of Africa has amounted to an approximate average of 10,000 bales per annum over the last seven years, and cotton would therefore seem to be either unsuited to those districts, or else to compete unfavourably with other crops. It would thus seem that no immediate expansion in cotton growing in Africa can be looked for outside the Soudan, Uganda and Nigeria.

Mesopotamia.—The British mandatory sphere comprises 150,000 square miles, only a portion of which could be brought under cultivation. The population is placed at 2,850,000, but this largely consists of town dwellers or roving tribes, neither of whom may be expected to take speedily to cultivation. Experiments have shown that the land is capable of producing cotton of excellent quality, eminently suitable for English mills, but the prospects of growing it on a large scale are not encouraging. Irrigation works of great magnitude are essential before any appreciable area may be brought under cultivation, and while the East remains in its present unsettled and lawless state, there is no probability of such works being commenced. The Mesopotamian rivers possess the disadvantage of bringing down a very large proportion of silt, which, although it serves to manure and rejuvenate the land, has the drawback of rapidly silting up the canals; furthermore, both the Tigris and the Euphrates contain a very high percentage of salt as compared with the Nile. During the summer the heat is intense and evaporation very great, resulting in irrigated land quickly becoming saturated with salt. The writer, during his two years' experience of that country, saw thousands of acres abandoned for this reason, the surface of the ground being so

slippery and slimy with salt as to make walking a matter of difficulty. If this ill-effect is to be overcome it must entail frequent washings and a very thorough system of drainage. It therefore does not appear likely that the quantity of cotton produced in Mesopotamia for many years to come will be worthy of taking into consideration.

British West Indies.—Area, 12,300 square miles ; population, 1,173,000. The quality of the cotton produced by these islands is the finest in the world : neither the products of Egypt nor America (excepting Georgia and a strip of land along the Florida coast) have ever succeeded in rivalling it in quality, and it may be news to many that Australia is perhaps the only country that has in the past produced cotton of equal quality to that of the West Indies. Unfortunately, the quantity of true West Indian Sea Island cotton is very small : the total crop of this variety during 1922 amounted to only approximately 4000 bales, and despite its high value, it need scarcely enter into our calculations when contemplating a deficiency of 6,000,000 bales in the world's supply.

Cotton Production within the Empire.—The table on p. 25, compiled from figures supplied by the Statistical Department of the Board of Trade, shows the quantity of raw cotton imported into the United Kingdom and consigned from British overseas dominions and protectorates (except India) and Portuguese East Africa, during the last five years. In order to show more clearly the increase in the production of new countries within the Empire, a final set of totals has been added, obtained by subtracting the Egyptian and Portuguese East African figures from the grand totals given by the Board of Trade.

The table on p. 26, taken from the Annual Report of the British Cotton Growing Association for the twelve months ending December 31, 1922, gives a truer idea of what has been achieved in new fields within the Empire.[1] The figures, be it noted, are those not of the cotton exported, but of the cotton grown.

It will be seen that, notwithstanding the appreciable increase in Empire production, the final result is regrettably small and does not go far towards meeting the world's shortage. Since the cottons of India and China are almost useless to the mills of England, America, or continental Europe, and as it appears evident that neither the size of the American crop

[1] Nos. I and II (January and April, 1924) of the *Empire Cotton Growing Review* give tables calculated in greater detail from a number of sources of information, and the figures agree very closely with these—which show the results conveniently in round numbers.

STATEMENT SHOWING THE QUANTITY OF RAW COTTON (*a*) IMPORTED INTO THE UNITED KINGDOM AND CONSIGNED FROM THE BRITISH OVERSEAS DOMINIONS AND PROTECTORATES (EXCEPT INDIA) AND PORTUGUESE EAST AFRICA, IN THE YEARS 1918, 1919, 1920, 1921 AND 1922, COMPILED FROM FIGURES SUPPLIED BY THE STATISTICAL DEPARTMENT OF THE BOARD OF TRADE.

Country.	1918.	1919.	1920.	1921.	1922.
	Bales of 400 lb.	Bales of 400 lb.	Bales of 400 lb.	Bales of 400 lb.	Bales of 400 lb.
Egypt . .	971,183	1,042,344	703,960	578,179	789,744
Anglo-Egyptian Soudan .	10,192	11,081	15,301	26,237	20,132
Gold Coast .	3	624	148	...	15
Nigeria . .	2,739	14,788	16,079	32,991	15,517
TOTAL, BRITISH WEST AFRICA .	2,742	15,412	16,227	32,991	15,532
East Africa and Uganda Protectorates .	9,491	20,160	36,121	22,406	23,397
Nyasaland Protectorate .	6,348	4,795	3,149	1,615	2,975
Portuguese East Africa . .	...	109	972	3,638	9,490
TOTAL, EAST AFRICA .	15,839	25,064	40,242	27,659	35,862
British West Indies . .	5,599	5,028	6,270	5,028	4,127
Ceylon and Dependencies .	...	600	120	...	110
South Africa .	489	1,882	3,910	3,224	3,726
Australia .	88	65	238	664	3,077
New Zealand .	22	...	...	...	...
Other British Overseas Dominions and Protectorates (except India)	266	1,268	711	762	2,271
GRAND TOTALS	1,006,420	1,102,744	786,979	674,744	874,581
British Empire only . .	35,237	60,291	82,047	92,927	75,347
Addendum : Former German West Africa .	433	3,202	1,953	Included in Nigeria.	Included in Nigeria.

(*a*) Including 'Linters' prior to 1920.

APPROXIMATE ESTIMATE OF COTTON GROWN IN NEW FIELDS IN THE BRITISH EMPIRE (Bales of 400 lb.)

Country.	1915.	1916.	1917.	1918.	1919.	1920.	1921.	1922.
Gold Coast	100	100	100	100	—	—	—	—
Nigeria :								
Southern Provinces	6,300	9,400	7,900	3,100	9,500	10,700	19,500	4,600
Northern Provinces	1,200	10,800	3,900	3,000	8,000	5,500	12,000	9,000
West Africa	7,600	20,300	11,900	6,200	17,500	16,200	31,500	13,600
Uganda Protectorate	25,200	25,100	24,000	23,000	35,000	52,000	81,300	40,000
Kenya Colony	300	200	200	200	100	100	500	400
Tanganyika Territory	—	—	—	—	—	—	7,500	5,300
Nyasaland and Rhodesia	9,000	8,500	6,500	5,000	2,200	3,500	4,600	5,700
Union of South Africa	390	330	380	640	2,000	2,500	2,500	2,800
East, Central and South Africa	34,890	34,130	31,080	28,840	39,300	58,100	96,400	54,200
Soudan	24,000	16,200	23,000	12,000	12,300	22,000	27,700	24,300
West Indies	5,600	3,500	3,000	4,500	5,500	4,500	4,500	4,000
Sundries	3,110	4,670	3,620	3,360	5,000	5,000	4,000	4,000
TOTAL	75,200	78,800	72,600	54,900	79,600	105,800	164,100	100,100
APPROXIMATE VALUE	£1,123,000	£1,500,000	£2,700,000	£2,349,000	£5,593,000	£3,617,300	£3,929,000	£2,716,000

nor the quality of the staple can be improved, there remain but three countries capable of meeting the world's deficiency, or of providing for future requirements—Africa, South America and Australia.

The African possibilities seem very promising and have already been discussed; it only remains to consider the countries of South America and Australia.

South America.—Brazil and Peru comprise the chief cotton-growing countries of South America: their combined crops during 1921 amounted to 769,000 bales of 478 lb. For the past five years there has been no appreciable extension in cotton cultivation and the prospects for the future are not too encouraging, even though these countries possess ample acreage for expansion. Unfortunately, much of the South American cotton, although of good length of staple, is very coarse and rough, more suitable for mixing with woollen goods than for manufacturing into pure cotton fabrics. Finer staple varieties might be introduced, but it must be remembered that considerable time is required to breed up any new variety to commercial proportions, and the difficulties to be faced or overcome in persuading cultivators to give up producing a familiar variety of cotton, with whose habits and requirements they are fully conversant, may prove to be greater than the task of introducing cotton amongst strangers in a virgin country. The prospects of South America producing any great quantity of cotton equal, or superior, to American Upland during the immediate future must, for the present, be considered uncertain, but the possession of a great amount of available land and a growing population clearly offer appreciable opportunities.

Future Prospects.—A very brief—and optimistic—forecast of the cotton production within the British Empire and Egypt, five years hence, may be estimated as follows:

Country	Estimated Production in Bales of 500 lb.
Egypt	1,000,000
Uganda	1,000,000
Nigeria	1,000,000
Soudan	500,000
Elsewhere in Africa	200,000
Mesopotamia	40,000
West Indies	10,000
British Empire	3,750,000 bales

No allowance has been made for any augmentation of the world's consumption of cotton, but, as during the last century there has been a steady and ever-increasing demand for cotton, it would seem reasonable to suppose that the world's capacity for the consumption of the raw material in five years time will be greater than it is now. Should Europe and Russia revert to anything resembling pre-war conditions the consumption of cotton may at least amount to what it was during 1914.

If this should prove to be the case, then there must be a grave shortage of cotton unless some other country can produce a very appreciable quantity within that period.

Australia.—Australian possibilities have not been discussed. How far, and to what extent, may that country with her high-paid white labour be able to produce cotton on a commercial scale and as a paying proposition?

CHAPTER III

COTTON IN AUSTRALIA, 1788–1920

Australian cottons—History of cotton in Australia—First shipment of Australian cotton—Valuation of Australian cotton in 1852—Cotton-growing experiment at Brisbane in 1857—How the American Civil War affected Australia — Australian production 1868–1873 — Bottomley Report—Production during the period 1907–1920.

Past experience furnishes ample proof that, in certain defined areas, Australia possesses the necessary requirements of climate, soil and rainfall essential for cotton production.

There are many recorded instances of efforts made to introduce and to cultivate cotton as a commercial crop. In all cases cotton appears to have been a success, where these experiments were carried out in suitable localities. One can discover no recorded instances of pests interfering with the plant to such an extent as to make its cultivation unprofitable, but, on the other hand, it is hard to obtain any definite past facts or figures relating to the cultivation and growth. This grave lack of authentic statistical information renders it a difficult matter for one to arrive at a true estimate of cotton's possibilities in Australia.

Australian Cottons.—There are certain indigenous wild cottons, and the variety known as *Gossypium Sturtii* seems to be confined to Australia alone. Two wild species are distributed between the 15° and 30° South latitude, namely in Western, Southern and Central Australia and Queensland. A tall and very ornamental wild cotton was originally collected in the year 1839 during the McDougall-Sturt journey into the interior of Australia, and it has since been found in other parts of the country, in the vicinity of Mount Watson, Lake Eyre, Central South Australia towards Spencer's Gulf, Mount Lyndhurst and Warburton. An imperfectly known but undoubted wild species is also found in Western Australia. These varieties produce a fuzz on the seed coat but no lint, and have, therefore, never been cultivated, nor does it seem

probable that they will ever contribute to the stocks of the world. The presence of indigenous wild plants would, nevertheless, appear to indicate that the country is capable of producing specified varieties of cotton.

History of Cotton in Australia.—Despite the meagre knowledge at our disposal a brief chronological history of cotton in Australia is interesting.

In May, 1787, the British Government dispatched an expedition to Australia under Captain Arthur Phillip, R.N., the first Governor of New South Wales. On his arrival at Rio de Janeiro he took on board many things that he thought might be of service to the new colony. In his dispatch written there on September 2, 1787, to Under-Secretary Nepean, he says :

'I have been able to procure all such fruits and plants as I think likely to thrive on the coast of New South Wales, particularly the coffee, indigo, cotton and cochineal.'

In 1801 Governor King took a keen interest in cotton growing on Norfolk Island, corresponding with Sir Joseph Banks on the subject ; during 1801, in a dispatch from N.S.W., he writes :

'Respecting cotton, much seed sown here, both from the Bahamas and the Isle of Bourbon. Experience has proved that it will not do here, but there can be no doubt of it succeeding further to the northward.'

As at this date there was no settlement north of Sydney, King's scant experience of cotton and his hasty condemnation would seem to be based on his knowledge of Norfolk Island, which is in the same latitude.

Some five years later a Dr. Luttrell came to New South Wales, and his efforts at cotton cultivation appear to have met with a certain amount of success, for in his letter to the Under-Secretary of State, in 1807, he says :

'As the climate of the country is suitable to the growth of the annual cotton plant, such as is the produce of the Carolinas, the cultivation of it as an exportable article for the China market would prove of great benefit to the Colony.'

Little or nothing is heard of cotton in Australia for some years, until 1828, when Mr. Charles Frazer, Government Botanist, grew a small quantity in the Sydney Botanical Gardens, and received a special prize from the Agricultural and Horticultural Society.

A typical Queensland Cotton Field. Photo taken whilst the first picking was in progress.

First Shipment of Australian Cotton.—In 1830 Mr. J. Maclaren of Sydney sent three bags of cotton to Messrs. Alston, Finlay & Co., of Liverpool, and this would appear to be the first recorded shipment of cotton from Australia. The shipment was submitted to public auction and realised 10¾*d.*, 11*d.* and 11¼*d.* per bag. It is reported to have been of good colour and strong, with a silky texture.

We are indebted to Dr. J. D. Lang, D.D., M.A., for the first authentic information, as frequent mention of cotton is made by him in his books entitled 'Cooksland' (1847), and 'Queensland' (1861). In the former work, when writing of one of his visits to Queensland, Dr. Lang says that he was much struck with the excellent condition of the cotton plants, which were to all appearance as healthy and vigorous as those he had seen in Brazil.

In 'Cooksland,' Chapter VI, he says he has submitted a 'specimen of Australian cotton, grown casually from American seed,' to an American house of the highest standing and experience in the cotton trade, who gave the following certificate in regard to its quality and value:

'GLASGOW, 15*th April* 1847.

'DEAR SIR,—We have examined the small sample of cotton wool from Australia carefully, and give as our opinion, that if quantity could be produced, it is a very valuable kind, and would, at the present state of the market, readily sell at, say, 11*d.* to one shilling per lb. It is clean in colour, fine stapled, but rather weak, which by care taken in cultivation might be much improved. We remain, dear Sir, yours most sincerely,

'JAMES AND JOHN WRIGHT.'

Valuation of Australian Cotton in 1852.—When Dr. Lang sailed for England he took with him numerous samples of cotton which were in due course submitted to experts in Manchester, and the following extract from the *Daily News*, of July 21, 1852, is of the greatest interest :—

'*Specimens of Cotton Grown in Australia.*

'Some specimens of cotton grown in Australia have been 'submitted by the Rev. Dr. Lang to the examination of Mr. 'Thomas Bazley, President of the Manchester Chamber of 'Commerce; and the opinion of this gentleman, who is ac-'knowledged to be a first-rate judge of the qualities of cotton,

'will be read with great interest, as showing that this quarter 'of the world gives promise of becoming one of the finest 'cotton fields which have yet been discovered in our Colonies, 'if not, indeed, in the world. . . .

'The following is Mr. Bazley's answer as submitted through 'the Secretary of the Chamber :—

"Chamber of Commerce and Manufacturers,
Manchester, July 15th, 1852.

"Reverend Sir :

"I have submitted the samples of Australian cotton, sent "by you to the Chamber yesterday, to the criticism of our "President, Thomas Bazley, Esq., whose knowledge and judg-"ment in such matters are not surpassed by any gentleman "connected with the trade. He has instructed me to make "the following report thereon, according to the numbers "adopted in your schedule :—

"(1) Grown by Dr. Hobbs, Brisbane: excellent cotton and in perfect condition for the spinner; value 22*d*. per pound.

"(2) Grown by Mr. Douglas, Ipswich: really beautiful cotton; worth, if perfectly clean, 2*s*. per pound.

"(3) Grown by the Rev. Mr. Gibson, 'Big Cream': very good cotton, but not well got up; worth 21*d*. per pound.

"(4) Grown by the same: very excellent, and in good condition; worth 22*d*. per pound.

"(5) Grown by the same: excellent cotton; worth 22*d*. per pound.

"(6) Grown by A. Lang, Esq.: short-stapled cotton, of the New Orleans class; worth 5½*d*. per pound.

"(7) Grown by Mr. Scobie: good cotton; worth 20*d*. per pound.

"(8) Grown by J. Bucknell, Esq.: good and useful cotton, but of the Sea Island class, now worth 18*d*. per pound.

"(9) Grown by the same: like the preceding; worth 17*d*. per pound.

"I am further instructed to assure you, that in the pre-"ceding estimates Mr. Bazley has been careful to keep within "the limits which, in his appreciation, their worth would "have led him to fix; and I am to express his opinion that "such superior and excellent produce of perfect cotton have

D

"been rarely seen in Manchester, and that your samples in-
"disputably prove the capability of Australia to produce most
"useful and beautiful cotton, adapted to the English markets,
"in a range of value from 6*d*. to 2*s*. 6*d*. per pound.

"I am, Reverend Sir,

"Your most obedient servant,

"THOMAS BOOTHMAN, *Secretary*."'

Until about 1850, cotton appears to have been grown chiefly as an ornamental plant, and no heed seems to have been taken of its commercial possibilities. Frequently, not even the variety is stated, and no mention is made of when the seeds were planted. Thus, up to this point, past Australian experience is of no use, beyond providing proof that cotton *could* be grown in that country.

Further interesting facts and details are provided by Mr. George Wight in his book entitled 'Queensland,' published in 1863. When discussing the possibilities of cotton growing in that State Mr. Wight says :—

'The soil varies, but is all admirably adapted to the growth 'of cotton in its best varieties, especially Sea Island. . . .

'In 1854, when Queensland was connected with New South 'Wales, a quantity of cotton grown there was submitted to 'Messrs. Hollingshead & Co., of Liverpool, for examination. 'The report of these gentlemen was in these terms: We have 'carefully examined the sample of Australian cotton sent us 'for valuation. It ranks with the highest class of Sea Island 'cotton, and, free from the few spots or stains, is worth 3*s*. per 'pound in this market. It is superior in fineness and even-'ness of staple, though a little inferior in strength of staple, 'as compared with Sea Island. We return you the sample, 'as you may not have retained any, and send you a small 'bit of Sea Island, worth to-day 2*s*. 6*d*. per pound, and 'another purchased to-day at 2*s*. 9*d*., both inferior to your 'sample, in our opinion, and in the opinion of the buyer of 'the 2*s*. 9*d*. lot.'

Mr. Wight then quotes from a letter written three years later, in 1857, by a Mr. Clegg, of Manchester, in reference to a sample sent to him :—

'I have no doubt that, where this was grown, they can 'produce, *in quantity*, the best cotton in the world perhaps, 'and ought forthwith to turn their attention to it, by

'getting abundance of labour either from China or from 'other sources, free from any risk of introducing slavery in 'its cultivation. . . .

'A gentleman, who has a son in Australia, has previously 'sent me samples of this cotton, and they cannot do better 'than begin to plant all in their power, and send it in 'quantity. I shall have great pleasure in selling such as 'they may send, to enable them to get the best possible 'price for it. To show that there is no risk I dare, at this 'moment, buy 500 bales, of from 300 to 500 lb. each, of 'this, at 2*s*. per lb. Do not, however, let them deceive 'themselves, but calculate, as one of themselves lately said, 'on realizing an average of 1*s*. 3*d*. to 1*s*. 6d. per lb. Even 'this would be a very high price, Indian cotton ranging from '3*d*. to 5*d*.; American bowed Uplands Orleans, 3½*d*. to 8½*d*.; 'Brazil, and similar staple, 5*d*. to 8*d*.; Egyptian, from 5½*d*. 'to 10*d*.; and Sea Island (your variety), 11*d*. to 2*s*., fine 'quality to 4*s*. per lb.

'At a meeting held in Manchester about two years ago, 'Mr. Bazley is reported to have addressed his audience in 'these terms regarding Queensland cotton and its cultivation:—

"About five years ago a few bags of Moreton Bay "(Queensland) cotton were shipped to Liverpool, and I saw "at once that, with such vastly superior cotton, yarn could "be produced finer than any that could be manufactured in "India or Great Britain. I bought that cotton, carried it to "Manchester, and spun it into exquisitely fine yarn. I found "that the weavers of Lancashire could not produce a fabric "from it, it was so exceedingly delicate; the weavers of "Scotland could not weave it; nor could even the manu-"facturers of France weave this yarn into fine muslin. It "occurred to me to send it to Calcutta, and in due time I had "the happiness of receiving from India some of the finest "muslin ever manufactured, the produce of the skill of the "Hindoos, with this delicate Australian cotton. At the Paris "Exhibition, some of this muslin was placed in the same "glass case with a large golden nugget from Australia, and "the two attracted much attention. The soil and climate "of Queensland are capable of producing, with proper care, "600 lbs. yearly per acre of this exquisitely fine cotton. I "value this cotton at 1*s*. 3*d*. per lb., which would be equal "to £40 per acre. This is no over estimate, for I have "recently given 1*s*. 8*d*. per lb. for Australian cotton. Now,

"£40 per acre is an enormous yield for any agricultural "product; and I do not think such a profitable return could "be obtained in any other country. Judging by what is "done in the United States, a man with his family in Queens- "land could cultivate ten acres of land, which would yield "£400 per annum—a very high rate of profit." '

Cotton-Growing Experiment at Brisbane in 1857.—The following extract from the same work is even more interesting, as it supplies us with particulars relating to the yield per acre. It refers to two experiments made by Mr. Walter Hill, the Director of the Botanical Gardens, Brisbane, in 1857 and 1858, on 'half an acre of ground on an open situation, of a sandy loamy soil.' After giving an exact account of the methods that were employed in the cultivation, the report says: 'The fibre and seeds of one hundred plants were kept separate in gathering each season. Each plant produced 11 ounces of seed and 4 ounces of fibre, yielding at the rate of 1871 lb. 6 ounces of seed, and 680 lb. 8 ounces of fibre per acre. Samples of the fibre were forwarded to England with the view of testing its quality and value. The report received stated the fibre appeared to the eye to be of excellent quality, and its value would be from 2*s*. to 2*s*. 3*d*. per lb. in London.'

The yield per acre of 1871 lb. is exceedingly high and is all the more remarkable when it is remembered that the Sea Island variety grown in Queensland was cultivated under natural rainfall conditions. It is much to be regretted that no records are available showing the monthly rainfall for the years 1857 and 1858, as it would be of interest to note the quantity of moisture which the plants received at various stages of their growth. As a general rule, cotton grown under irrigation has the advantage over that produced under rainfall conditions, that in the former case it is possible to regulate the moisture contents of the soil to meet the plant's requirements, but in the latter case this is without our control. In respect of this, it is worthy of note that the yield mentioned by Mr. Hill is 30 per cent. greater than that attained in Egypt during 1901–2, and is nearly double the average yield obtained in Egypt at the present day. We may safely place reliance on Mr. Hill's figures, seeing that he was a botanist of great experience, and they are in the main substantiated by Dr. Lang, who, in Appendix F to his book entitled 'Queensland,' 1861, states:—

'A good average crop is 1600 lb. of seed cotton per acre,

but will yield 400 lb. of clean lint, or one bale worth always not less than £30.'

Even the foregoing high yields have been eclipsed by those obtained in Australia during recent years.

Between 1858 and 1861 little mention is made of cotton, and practically only experimental plots appear to have been grown. In 1862, 14,344 lb. of lint, equivalent to 29 bales of approximately 500 lb. each, were produced in Queensland.

How the American Civil War Affected Australia.—The American Civil War and its resultant cotton famine gave a great impetus to the Australian cotton industry, which seems to have been confined almost entirely to Queensland. A few definite facts are available during the period 1863–64, when Mr. Panton of Ipswich, Queensland, grew 10 acres of Sea Island variety This area produced 14 bales of clean cotton lint weighing 3238 lb. net, which realised 36*d.* per lb., and the seed fetched 28*s.* per cwt. A profit of £437 11*s.* 6*d.* is mentioned in respect of this parcel. During the period of the War a certain amount of cotton was also produced in the Northern Rivers District of New South Wales.

Australian Production, 1868–73.—During 1868 to 1873 Queensland's cotton production assumed moderate proportions, as the following figures indicate :—

Year.	Quantity in lb. Lint.	Approximate Number in Bales of 500 lb.
1868	1,809,628	3,619 bales
1869	1,118,899	2,238 ,,
1870	1,630,755	3,261 ,,
1871	2,602,100	5,204 ,,
1872	1,486,987	2,972 ,,
1873	1,375,216	2,750 ,,
Total 6 years	10,023,585 lb.	20,044 bales

From 1873 onwards there was a rapid decrease in Australian cotton production which seems to have been due to a reversion to normal conditions in America and to the employment of very cheap coloured labour in that country. The fact remains that during the year 1891 Australia only produced 15,396 lb. of lint or approximately 30 bales of cotton of 500 lb. weight.

Between 1891 and 1907 the industry appears to have remained stationary, although there seems to be no lack of proof that cotton was well suited to Australian climatic conditions.

During the period 1898–9 an interesting experiment was carried out by Mr. A. M. Howell for the New South Wales Department of Agriculture at the Moonbi Experimental Farm, on the North Coast District of New South Wales, and although the experiment was but on a small scale it suggests considerable information. It is the more valuable in that the cotton in this case was American Upland—of the variety known as 'Peterkin.' The area was of two acres. The seeds were planted on October 29, and Mr. Howell states that the young plants were up to a practically perfect stand within five days—nearly all in four days. The first buds or forms appeared on December 18, fifty days after planting, which is about the usual length of this period ; on January 7 the first open flower was seen, 70 days after planting, or a week earlier than the usual time. On February 21 the first open boll was seen, or 115 days after planting, this being five days less than what is recorded in South Carolina as the minimum period from planting to the first open boll.

The yield of seed cotton per acre amounted to 466 lb. which, considering the season had been exceptionally dry during the growing period, is quite a good result. Mr. Howell's closing remarks are : 'Cotton held its own, with a fortitude and persistence that were remarkable.'

Bottomley Report.—In 1904 efforts were made by the Australian Government to investigate the true cotton possibilities of the country, and extracts from the official report written by Mr. John Bottomley at Palmerston, Northern Territory, on December 15, 1904, to the Hon. J. G. Jenkins, Premier of South Australia, Adelaide, prove of interest in this respect. Mr. Bottomley says :—

'I have spent about six months in Queensland, acting on 'the Commission appointed last January by the State Government for the purpose of ascertaining whether cotton could 'be successfully grown by white labour. An officer of the 'Department of Agriculture accompanied me, and we both 'traversed the State, interviewing farmers, examining soils, 'etc., and the results of our investigations were embodied in 'a report, which the Government forwarded to the British 'Cotton Growing Association, of Manchester. We came to the

An Australian Cotton Field, Penrith, New South Wales.

'conclusion that cotton could be successfully cultivated by the 'farmers in small and easily worked areas (from 5 to 10 acres), 'as an adjunct to other crops; but that it could not be suc-'cessfully grown in large plantations in the absence of cheap 'coloured labour. . . .

'The soil and climate are well adapted for the growth of 'cotton, especially on the lands near the coast where, in my 'opinion, the conditions for the successful cultivation of the 'Sea Island or long-stapled varieties are all that could be 'desired. I also visited Pine Creek, 146 miles inland from 'Palmerston. The greater part of the country bordering the 'railway line from Palmerston to Pine Creek is suitable for 'cotton growing, the soil being of a light, sandy nature, and 'lightly timbered. In consequence of the distance from the 'coast, the Sea Island varieties cannot be grown here. I 'would, however, recommend that the shorter stapled varieties 'be cultivated. There seems to be no doubt but that the 'country is well adapted for the successful cultivation of the 'latter kinds. Moreover, they do not require the same careful 'and close supervision as is the case with Sea Island, and on 'that account the aborigines of the district could be very well 'employed at picking the crop, if they can be induced to work; 'but on that point I cannot express an opinion. Only the 'Upland varieties should be grown here. Different kinds 'of cotton have been tried at the experimental nursery at 'Palmerston with very gratifying results. During last season 'twelve varieties were cultivated. The cotton plant has been 'grown in light, sandy soil, on a dark, well-drained loam, and 'in the ferruginous, gravelly soil typical of Palmerston. The 'plants seem to thrive equally well in either of these soils. . . .

'In conclusion I would say that it seems to me the Northern 'Territory possesses unlimited possibilities for the successful 'cultivation of the highest grades of cotton over a very large 'area of coastal country, and of Upland varieties further 'inland, the labour difficulty alone standing in the way.'

A full perusal of Mr. Bottomley's report shows that he was thoroughly convinced that Australia possesses very large areas admirably suited for successful cotton cultivation, but that he had grave doubts on the question of labour, and is sceptical concerning Australia's possibilities of entering into open competition with other cotton-growing countries, unless she can obtain cheap coloured labour. It remains to be proved whether or not he is correct.

Production during the Period 1907–20.—From 1907 to 1920 the industry made no progress and the output was trifling, as the following figures indicate :—

Year.	Lb. of Seed Cotton.	Bales of 500 lb.
1907	109,294	73 bales
1908	117,521	78 ,,
1909	129,245	86 ,,
1910	151,438	101 ,,
1911	186,894	124 ,,
1912	150,414	100 ,,
1913	34,230	23 ,,
1914	20,336	15 ,,
1915	12,238	8 ,,
1916	24,264	16 ,,
1917	118,229	79 ,,
1918	166,458	111 ,,
1919	37,238	25 ,,
1920	57,065	38 ,,

Australia possesses large tracts of land endowed with the requisite soil, climate, and rainfall ; we have proof that the country has produced and can produce cotton of excellent quality ; there must therefore be definite reasons to account for her past inability to figure prominently amongst those countries which annually contribute their steady quota of cotton towards the world's crop.

It is, therefore, essential to investigate fully all causes that may in any way be held responsible for past failures, as unless we are aware of these we cannot gauge Australia's present or future cotton possibilities ; nor can we estimate her chances of success in meeting competition from those countries that have for many years made cotton growing a profitable industry.

CHAPTER IV

PAST AND PRESENT COTTON-GROWING CONDITIONS

Part I.—Past Conditions. Growers' difficulty in disposal of crop—Slow and uncertain local and oversea transport—Lack of business organisation—Scarcity of population—Laxity in methods of cultivation—Fluctuation in values—Cost and difficulty of obtaining labour.

Part II.—Present-day Conditions and Future Possibilities. Disposal of the crop—Transport facilities—Business organisation for marketing the crop—Scarcity of population must control the size of the crop—Methods of cultivation—Fluctuation in values—Cost of production: Government figures, growers' figures—Yields—Average Australian yields—Fair average estimate of cost of production—American cost of production—American versus Australian costs of production.

PART I.—PAST CONDITIONS

Why has Australia in the past failed to make a permanent commercial success of cotton growing? No individual factor has been directly responsible; but the collective weight of numerous causes and of lesser detrimental effects that, as a matter of course, have followed in their wake. Briefly summarised the main causes have been:

The growers' difficulty in disposing of their crop.
Slow and uncertain transport.
Lack of business organisations for marketing.
Scarcity of population.
Laxity in methods of cultivation.
Fluctuation in values.
The cost and difficulty of obtaining labour.

If it can be proved that the foregoing may be overcome, then the future success of the industry would seem to be assured. Each cause must be dealt with in turn, and it will help to clarify the situation if we also compare the obstacles that faced growers in the past with the position of affairs as they stand at the present day.

Growers' Difficulty in Disposal of Crop.—Half a century ago growers could not sell their cotton locally and were forced to

ship it to England for sale in Liverpool. Consequently, in addition to the expense of cultivation, picking and ginning, they had also to pay heavy freight charges, and then had to wait for the best part of a year before they received payment for their crop.

Slow and Uncertain Local and Oversea Transport.—The risk, delay and cost of transport in the days of sailing ships, unmade roads and practically no railways are obvious and need not be elaborated. In particular, these disadvantages, though they also affected stock-raising and the wool industry, did not affect them to nearly the same extent that they did cotton. Cattle could be driven to the market and required neither roads nor railways. Wool was shorn from the sheep in the up-country station, pressed into compact bales, and carted direct to the ship's side ready for shipment overseas. Also wool could better withstand this expense than cotton, as it has always realised a higher price per pound. Seed cotton, on the other hand, is bulky stuff, which cannot be compressed to the same density as wool and, furthermore, two-thirds of its weight is composed of the seeds, which at the time we speak of were quite valueless.

Lack of Business Organisation for Marketing.—The quantity of cotton being grown was small, and the existence of the various drawbacks did not encourage business men to look for an increase; consequently there was no incentive for them to erect ginning factories. Only two quite small ones existed in Queensland—at Harrisville and Ipswich, near Brisbane—and one at or near Sydney in New South Wales.

It is essential to remember that only half the battle of commercial success lies in the production of a good quality article, and that the other half lies in the successful marketing, coupled with the creation of a demand for the article produced; and further, that unless there is a steady and assured supply, it is almost impossible to create a keen demand. This is particularly the case with cotton. Every spinner and weaver knows that a particular class and variety of raw cotton produces a particular kind of yarn; a particular kind of yarn produces a cloth of known texture, strength, quality, and colour when dyed. In the case of new varieties it cannot be foretold how they will behave in the subsequent stages of manufacture, nor whether the finished article will give satisfaction to the purchaser. Consequently a spinner who experiments with new growths risks not only his own good

name but also that of his clients. This aversion to the employment of new growths is founded on fact and is universal throughout the cotton trade, forming an obstacle that every new cotton-growing country has to face, as naturally it applies with additional force at the outset when only very limited quantities of the new cottons are available. Under these circumstances neither brokers nor merchants could be expected to push the sale of the little known and small available quantities of Australian cotton, and naturally gave preference to the American product.

Scarcity of Population.—Cotton almost comes under the heading of crops requiring intensive cultivation, and is thus well suited to those districts and countries that are at least moderately thickly populated.

It was not to be expected that early settlers in a virgin and unpopulated country would cultivate the soil when there were millions of acres of fertile land, with ample rainfall and a temperate and even climate free from severe winter frosts, available for raising stock. Thousands of square miles of good grazing country could be had for the asking or be purchased from the Government for a mere song. Sheep were far more profitable than crops, for they reared themselves and only required to be shorn once a year; one man could look after thousands of acres of grazing country with small effort or expense to himself. Thus, until such time as increasing population raised the price of land and decreased the size of holdings, no great amount of cultivation could be expected.

Laxity in Methods of Cultivation.—We are now aware that if certain laws and precautions are accurately attended to, a pure strain cotton plant will behave with mathematical precision, and we know also many other facts having a direct bearing on the quality and characteristics of the fibre. We are aware of cotton's susceptibility to hybridisation, of the necessity for keeping a strain pure, and of the erratic behaviour and deterioration in both the fibre and the yield of descendants of impure plants. Our predecessors had not this knowledge, and those who attempted to improve a strain by selection of seed from large or prolific yielding plants, were almost always selecting from the hybrid plants, with the result that the changes and deterioration in the offspring were both baffling and discouraging to the investigators. True, Australia was no more handicapped or ignorant in this respect than America or other cotton-growing countries, and possibly the main reason

Eight Acres of Cotton grown by W. Middleton, Gunyan Station, Dumaresq River, on the border of Queensland and New South Wales. Season 1922–23.

for her ill-success in the past is to be found in her almost ideal cotton-growing climate. This may sound absurd, but is true, nevertheless. The climate made possible the practice of ratooning.

America might quite possibly have made the same mistake as Australia, were it not for the fact that she was prevented by her climate. Throughout the greater portion of the American cotton-belt, the winter frosts are of sufficient severity to kill all cotton plants that are left standing in the fields, thus rendering it impossible for the same plant to produce cotton for more than one season. Whether they wished it or not, American growers were compelled to sow the seed afresh each spring, and although cotton is a perennial plant by nature, climatic conditions in America forced it to be cultivated as an annual.

Cotton in Australia was faced with no such climatic limitations, for in Northern New South Wales and in Queensland the winter frosts are not severe enough to kill full-grown plants. The inevitable result was that the cotton flourished as a ratoon or perennial plant. Some growers chopped off the old bushes, leaving only a short stump protruding above the ground, others pruned the main branches; and the practice of ratooning cotton was universally employed and recommended.

Even in quite recent times, responsible officers of State Agricultural Departments have given similar advice, and growers were in no way to be blamed for following it, even though in view of latter-day experience we know this advice to have been quite wrong, and have proof that the growing of cotton as a perennial or ratoon plant must prove detrimental to the cotton industry and the good name of any country that resorts to it.[1] The cultivator's main objective was to obtain a good return from his crop, and it was absurd to expect him to know at once the commercial value of his product, such as the quality and strength of the fibre, the percentage of waste, or how it would spin. Ratooning his crop saved great labour, so he naturally adopted that method.

Fluctuation in Values.—When the American Civil War cut off the source of supply upon which the world then almost entirely relied, the keen demand for what little cotton there was available naturally forced prices to a very high figure, and the zenith was reached in 1863 when America received an average price of 52·8 cents (about 26*d.*) for every pound of

[1] See pp. 57, 58.

cotton she exported. These high prices encouraged Egypt, India and Australia to turn their attention to cotton production.

After the war the demand for several years continued to exceed the supply, and from 1865 to 1870 the price of cotton averaged about 18 cents per lb., or almost double what it was previous to 1860. These high prices, besides encouraging the growing of cotton in new fields, also prompted America's cheap coloured labour to turn its attention to cotton growing with renewed vigour.

During the above period, 1865–70, the Australian industry not only held its own, but also expanded. This was partly due to high prices, and partly to fostering on the part of the Australian Government, which gave a bonus on exported cotton varying from £2 10*s*. to £10 on each 400 lb. bale.

In 1870 America produced a crop of 4,034,598 bales, the largest since 1861, and almost double that of the five preceding years: consequently prices fell to 13·2 cents per lb. At the same date the Australian cotton bonus was removed by the Government, and the Australian industry was left to stand or fall on its own merits. From 1862 until 1871, at which latter date Australian cotton exports totalled 5204 bales, the acreage had showed a steady increase, and the presence of fair quantities of the product of first year plants had done much to counteract the ill-effect of ratoon lint in the crop. On the withdrawal of the Australian Government bonus and the fall in prices in 1870–71, no fresh areas were planted with cotton in Australia, and from then onwards all cotton grown appears to have been the product of perennial plants: the weak, wasty and irregular fibre of which was utterly unable to compete with the sound, strong fibre of American annuals.

Another effect of the fall in cotton prices was that, from 1871 onwards, the return per acre did not equal that from maize, for which there was a demand as fodder. Moreover, this demand being local, growers could obtain prompt payment for their maize crops, which, as we have seen, they could by no means do for their cotton.

Cost and Difficulty of Obtaining Labour.—Owing to the small population per square mile and the large areas of fertile land available for raising stock, it was a very difficult matter to obtain labour for the cultivation and the picking of cotton. Men preferred to work for themselves rather than for wages, and more profit was to be made by the rearing of sheep; consequently, labourers who had any ambition accumulated

a little cash and then launched out on their own; to their credit let it be said that most of them succeeded in 'making good.'

Ultimately the Australian cotton industry literally fizzled out, for in 1891 the total production only amounted to approximately 30 bales.

The foregoing causes represent the main reasons for Australia's past inability to make a success of commercial cotton production. None are incapable of being remedied. During the last fifty years conditions have materially altered and, even though obstacles still exist, the situation to-day presents a totally different aspect.

PART II.—PRESENT-DAY CONDITIONS AND FUTURE POSSIBILITIES

Disposal of the Crop.—In order to encourage the production of cotton in Australia, the various State Governments, working in conjunction with the Federal Government, have guaranteed growers a minimum price for every pound of sound, clean, annual seed cotton produced and handed over to the Government for ginning.

Although there are minor differences in price and detail between the guaranteed advances of the various States, the general conditions are as follows:

Season 1923–24.—Fivepence halfpenny per lb. for all annual seed cotton of good quality, free from disease or defects, of one and a quarter inch staple or upwards.

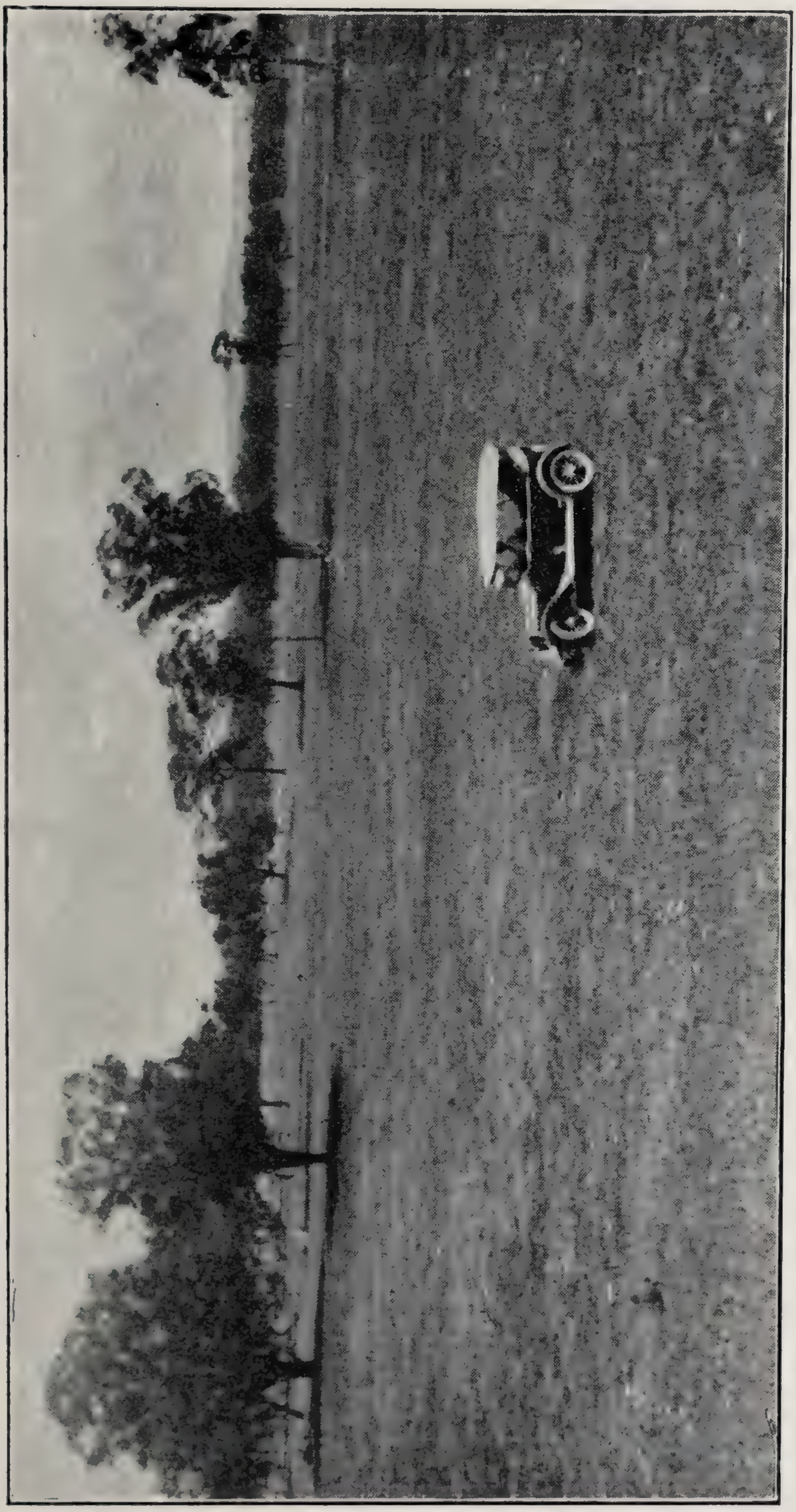
Fivepence per lb. for all sound seed cotton of lesser staple than one and a quarter inch.

Season 1924–25.—Fivepence per lb. for all sound seed cotton of one and a quarter inch staple or over.

Fourpence halfpenny per lb. for all sound seed cotton under one and a quarter inch staple.

Season 1925–26.—The guaranteed advance for the above-named period has yet to be fixed. It is, however, considered probable that the conditions will be the same as for the 1924–25 season, but that the respective prices will be reduced by one halfpenny per lb.

No advance whatever will be made upon ratoon cotton; while seed cotton found to be not of good quality, stained, dirty, or otherwise damaged, may be rejected, or accepted at a lesser price.



Rich Alluvial Flats on Gunyan Station, Dumaresq River, Queensland, suitable for Cotton Growing.

The advances mentioned are minimum advances, and any profits accruing, after deducting the cost of ginning, handling and marketing, will be divided, *pro rata*, amongst those who supplied seed cotton.

The Governments have taken a very broad-minded view of the situation and, whether the present revival of cotton growing in Australia succeeds or fails, the States concerned have done their utmost to give it a fair start.

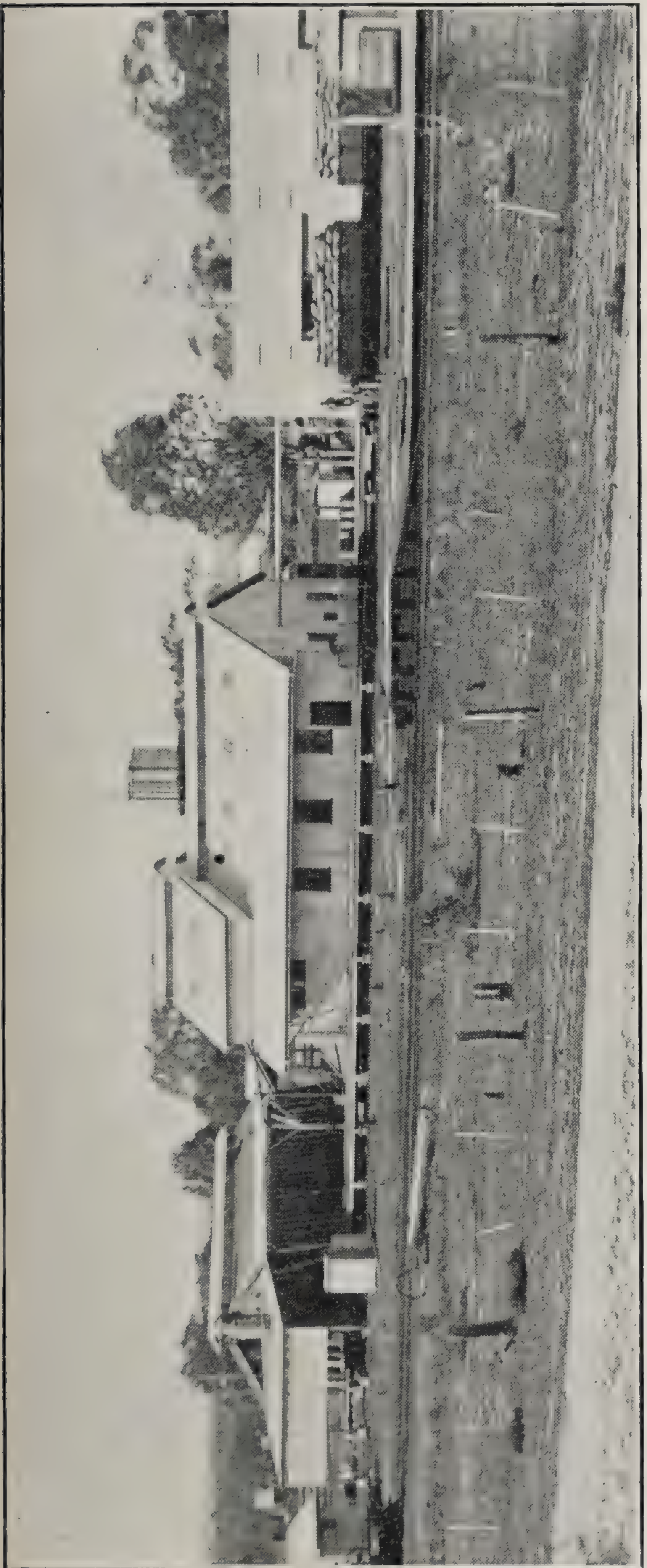
It will thus be seen that to-day, even before a grower plants his crop, he is aware of the minimum price he will obtain for every pound of seed cotton he produces, while there is always a possibility of receiving a surplus over and above the guaranteed price, if the quality of his cotton warrants it. Further, there is to-day no long period of waiting between the crop being picked and the grower receiving payment, and one of the greatest obstacles to the growing of cotton in Australia, in the past, has been removed.

Transport Facilities.—Graded roads, motor transport, railways and steamships now permit of the crop being moved rapidly and with comparative ease. Many of the country roads are not metalled, but they are almost all graded and the worst creeks are now bridged, while carting takes place during the dry season of the year when the roads are in good condition. While the bulkiness of seed cotton, and the fact that it cannot be densely compressed at the farm, makes it in one way awkward to handle, yet it facilitates loading, as the sacks are comparatively light.

Notwithstanding the fact that there still remain vast areas of land unserved by railways, the mileage of railway per head of population in Australia is greater than in any other country in the world, and is, per head, more than double that of the United States of America.

As all cotton in Australia is grown fairly close to the coast, it has only to be transported by rail for comparatively short distances, and this greatly decreases the cost of marketing the crop. It will be found that the average mileage of rail transportation in Australia is less than in America ; and infinitely less than the average mileage of cotton from the Anglo-Egyptian Soudan, Uganda and many parts of Nigeria to the sea-coast.

Thanks to steamships and the Suez Canal, Australian cotton may now be landed on the wharf at Liverpool or Manchester—with little or no risk attached to this overseas voyage



GAYNDAH GINNING PLANT, QUEENSLAND.

ROCKHAMPTON, QUEENSLAND—GENERAL VIEW OF GINNING PLANT.

—within forty to fifty days after the date of shipment from an Australian port. Such was not the case half a century ago.

Business Organisation for Marketing the Crop.—The fact of the Governments of the various States guaranteeing growers a minimum price for their crop has not only stimulated the production of cotton but has also given birth to an organisation for handling and marketing it.

In 1921 the Australian Cotton Growing Association (Queensland), Ltd., having a nominal capital of £200,000, was formed with the foregoing objects. One ginning factory was erected at Rockhampton and one at Whinstanes, near Brisbane. During the 1921–22 season, the area planted with cotton was estimated at between 5000 and 7000 acres. Rockhampton ginnery dealt with 2,382,587 lb. and Whinstanes ginnery with 1,504,693 lb. of seed cotton; the output of these two ginning factories amounting to 2573 bales of lint of 500 lb. each.

So swift was the expansion of the industry that by November, 1922, some 14,000 growers had applied for seed sufficient to plant 140,000 acres with cotton in the 1922–23 season, and the two existing ginning factories would have proved utterly inadequate for handling this crop. Further capital was, therefore, needed immediately for the erection of new ginneries and oil mills.

In order to provide the necessary capital, a new company was formed towards the end of 1922, and the assets, rights and goodwill of the Australian Cotton Growing Association (Queensland), Ltd., were acquired by the British Australian Cotton Association, Ltd., having a nominal capital of £1,000,000. This latter concern was appointed the duly authorised agent of the Federal and State Governments for the ginning and marketing of the Australian cotton crop during the term of the Government guaranteed prices to growers, provided that the Association on its part erected the necessary plant for efficiently dealing with the crop. The British Australian Cotton Association, Ltd., therefore immediately launched out in the work of construction, and by the late spring of 1923 one 80-ton per twenty-four hour capacity cotton-seed oil mill was in course of erection, and six large saw-ginning factories were in operation in Queensland; one saw-ginning factory in New South Wales, and one roller-ginning plant near Swan Hill, on the River Murray, for treating long-stapled cotton, were also completed.

To-day the procedure for the disposal of the crop is as follows. The growers pick, bag and place their seed cotton on rail, consigning it to the Association's nearest ginning factory. On arrival at the ginnery the cotton is carefully weighed and a weight note in triplicate is issued : the original is sent to the Government, the duplicate is dispatched to the grower, and the triplicate is retained by the Association. The Government, on receipt of these detailed weight slips, sends cheques direct to growers for the net value of the consignment, thereby enabling them to receive payment within a week or two of the cotton being dispatched from the farm.

The Association gin, bale and export the cotton to duly appointed brokers in Liverpool, who offer it for sale on the open market and sell to the highest bidder. Owing to its general good quality, Australian cotton has been ready of sale and has realised an average price of about 1*d.* per lb. above American Upland cotton of similar grade, or approximately 2*d.* per lb. over American Middling.

Proceeds of sales in Liverpool are paid to the Agents-General in London of those States who made growers an advance on their cotton ; and the States concerned pay the Association the agreed-upon commission for ginning and selling the crop.

As previously stated when we referred to the Government guaranteed prices to growers, should the cotton when sold realise a greater price than will reimburse the Government and also cover the cost of ginning, transportation and commission on the sale, the growers receive any such surplus, *pro rata* with those who supplied the cotton. If, on the other hand, the sale price is insufficient to cover the above expenses, then any loss is borne in equal proportions by the State and the Federal Governments.

One very important feature that should go far towards assuring the future success of cotton in Australia is perhaps best evidenced by the fact that, in addition to many influential Australians and growers who are shareholders in the British Australian Cotton Association, Ltd., Lancashire spinners and merchants have also rendered practical financial support, and now possess very considerable vested interests in this Association. This inclusion of members of the English cotton trade creates confidence in the venture, tends to stabilise the industry, and to a certain extent guarantees that if at any future date, owing to the expansion of the industry, it becomes necessary to increase the capital of the company to more than

£1,000,000, a ready response may be counted on from the Lancashire cotton trade. In a sense this company is a co-operative association, as all interested parties are directly represented, and the 'factor' or middleman is eliminated.

We thus find that there now exists a powerful organisation for disposing of the crop as speedily and as efficiently as possible; with the result that the growers receive the maximum return for their labours, as their product passes through the minimum number of hands; and that which was lacking in the past—a business organisation for disposing of the crop—is to-day an accomplished fact.

Scarcity of Population must Control the Size of the Crop.—Even though this obstacle still exists, it is to-day present to a lesser degree than in the past. The population of Australia is steadily increasing, for, in addition to the natural increase, each year brings its steady quota of immigrants. Despite this yearly influx of new inhabitants, the population per square mile is regrettably small; yet nevertheless an unmistakable change is gradually taking place, and the larger stations comprising upwards of 100,000 acres are perceptibly diminishing in number. Especially is this the case in proximity to the sea-coast, as the fertile soil and good rainfall of the coastal districts render them eminently suitable for closer settlement and the cultivation of crops. We thus find the population densest near the sea, and consequently the value of land in these areas, has increased; thereby driving the grazier farther inland where the land is cheaper and the rainfall, although less than in the coastal districts, is yet ample for the raising of stock.

We find that to-day there is a belt of land near the sea-coast that is comparatively thickly populated (for Australia), and it is to this area of fairly dense population that we must look for any rapid expansion of cotton cultivation in the immediate future. Such being the case, it follows that the controlling factor governing the size of the Australian cotton crop lies in the rural population of her cotton belt.

It seems certain that within the next few years the production of cotton must very materially increase, as there are now a great number of small farmers who find it a very profitable crop; but if this expansion continues at its present speed it cannot be many years before the country attains its maximum production per inhabitant. When once this point is reached, then any further extension must depend almost

entirely on an increase in the agricultural population, over and above its present figure. As millions of acres of first-class land possess both the rainfall and the climate essential for the successful production of cotton on a commercial scale, many years must elapse before land limitations enter into any calculations relating to the size of the Australian cotton crop; and we can with safety leave this aspect of the case alone and confine our attention to the limiting factor of the rural population.

In the Official Year Book of the Commonwealth of Australia, 1922, the following statistics are given under the date of April 4, 1921:

RURAL POPULATION

New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Northern Territory.
664,453	571,747	360,500	193,963	129,764	2,407

Although the rural population exceeds 2,000,000 persons, due allowance has to be made for the fact that in some States the greater portion of the farmers inhabit areas that lie without the cotton belt, and are therefore prevented by climate or rainfall from cultivating cotton. Further, one cannot in fairness count upon more than half the agricultural population of the cotton belt producing cotton, as in some localities sugar cane, fruit, dairying, maize or lucerne give a greater return per acre than cotton. It will doubtless be objected that even half is an unreasonably high proportion. But we are considering population as a *limiting* factor. We do not say that half *will* grow cotton, but *may* grow cotton. If we base our calculations, therefore, on fifty per cent. of the farmers situated in the cotton belt eventually growing cotton, we should arrive at a fair estimate of Australian possibilities with her present population. Families are not as a rule very large, so we may reckon one person in five to be a working man.

One-fifth of Queensland's rural population of 360,500 is 72,100, and, as these inhabit country that is admirably suited to growing cotton, at least half—namely, 36,050—may be counted as potential cotton growers.

In New South Wales, however, only approximately half the State is capable of cotton production under natural rainfall

conditions and, in consequence, we may only rely on one-quarter of her agricultural population of 664,453, *i.e.* 132,891 working men; that is, a possible 33,223 growers for that State.

The position is very different when we come to the other States of the Commonwealth, for, owing to climate and rainfall, only a very small proportion of their rural population can hope to cultivate cotton with any measure of success. Thus, in Victoria and South Australia, only those farmers living in proximity to the River Murray, and whose lands are capable of irrigation, can be counted as possible cotton producers. The majority of Western Australia may be excluded from our calculations, as, with the exception of the Kimberley District in the far North West, that State is unable to grow cotton by reason of its unfavourable rainfall. The district known as Arnhem Land, or the northern portion of the Northern Territory, has great possibilities, but the ridiculously small population of this State renders it a negligible quantity, and hardly worth consideration in our present calculations. Thus, in Victoria, South Australia, Western Australia and the Northern Territory the number of farmers capable of producing cotton might be estimated at 10,000, only half of whom should be counted upon for actual results. A summary of the situation gives us the following figures :—

State.	Rural Population (Men).	Percentage of Population available for Cotton Growing.	Possible Cotton Growers.	Area at 10 Acres per Grower.
Queensland . .	72,100	50%	36,050	360,500
New South Wales .	132,891	25%	33,223	332,230
Other States . .	10,000	50%	5,000	50,000
Commonwealth . .	214,990	...	74,273	742,730

If we base our calculations on an average yield of 600 lb. of seed cotton (*i.e.* 200 lb. of lint cotton) per acre, which is a very conservative estimate and is scarcely a fair return during a normal season, it gives a possible annual production of 297,092 bales of 500 lb. weight.

It is very hard to form any estimate of what the number of immigrants in the immediate future may amount to ; and although it seems possible that there may be an influx of

farmers into the cotton-growing areas of Queensland and New South Wales, from the drier regions of these States or from other States, it is difficult to foretell the extent of such local migration or how it may affect the production of cotton. It does, however, seem clear that, provided no such influx occurs and that the size and the distribution of the rural population remains appreciably unaltered, the Australian crop cannot exceed 300,000 bales annually; any expansion over and above this figure must be in direct proportion to an increase in the agricultural population of her cotton belt.

Methods of Cultivation. — Australia possesses a unique advantage in the fact that she is able to profit from the experience of other countries, such as Egypt and America, where cotton has been cultivated continuously for the last century: much of the dearly purchased experience of these countries may now be obtained from books, tables of statistics or from the experience of men who have acquired a practical knowledge of cotton growing in other parts of the world. This should prevent Australia from making grave errors in the cultivation of cotton and enable her to make the most of the opportunity that now presents itself. Years of untiring scientific research and countless experiments in other cotton-growing countries have resulted in the evolution of improved strains of cotton that either mature earlier or else give larger yields of better quality lint than the varieties previously cultivated, and the seed of these may now be purchased by any new country, such as Australia, that wishes to commence cotton growing on a commercial scale.

Insect pests of all kinds have received the closest study of numerous entomologists in various countries, and in many cases the habits and the life-history of the world's principal cotton pests, together with the most successful methods of combating them, have been discovered.

Australia has not been slow in availing herself of this wealth of information, and is to-day profiting by the Egyptian lessons in relation to ratooning and water-logging of the soil, and by American experience with regard to lack of control over seed distribution, insect pests and the detrimental effects of growing cotton on the same land year after year.

As concrete proof of the ill-effects attendant upon the ratooning of cotton, to which we have already referred, it may be well to quote two definite instances, namely, the experience of a certain island in the West Indies, and of Egypt. During

the European War, all true Sea Island cotton was commandeered by the British Government for the manufacture of aeroplane or balloon fabrics. The product of one particular West Indian island was found to be so markedly inferior to that of others in the same locality that the British Government refused to purchase it, and fuller investigation brought to light the fact that this island was cultivating the Sea Island variety as a ratoon, or perennial plant, instead of as an annual as was the practice in the neighbouring islands.

The Egyptian winters are not sufficiently severe to kill full-grown cotton plants, and there was a period when many of the Egyptian cultivators grew cotton as a perennial. Experience in that country proved this practice to be so detrimental to the quality of the cotton and to increase so much the damage caused by insect—as the ratooned plants formed a natural breeding ground and place of hibernation—that the entire Egyptian cotton-growing industry was jeopardised. In order to safeguard the industry, which is worth some £30,000,000 to £40,000,000 per annum to Egypt, the Government was compelled to pass a decree in 1909 prohibiting the ratooning of cotton and forcing the natives to uproot and remove all old plants from the fields by December 31 of each year, and thus as far as possible eradicate the cotton pests by depriving them of their food during the winter months.

Profiting by this Egyptian experience, the Government of New South Wales has from the outset prohibited all ratooning of cotton in that State, and the Queensland Government has recently taken similar action despite vigorous protests from many inexperienced Queensland growers, who remember their fathers' ratooning of cotton in the 'seventies, and who still wish to continue this pernicious practice. Both these States have taken a further wise step in insisting on the fumigation of all cotton seed that is dispatched to growers for planting purposes; the treatment of the seed being the same as that universally employed in Egypt. This fumigation is not essential at present, for there are as yet no serious pests in the Australian cotton belt; but the wisdom of the course cannot be questioned, for one has only to turn to America for proof of the terrible havoc that may be caused through the agency of insects, and prevention is better than cure.

Even though there are few irrigation areas in Australia, it is interesting to note that in the largest and most important of these—namely, the Murrumbidgee Irrigation Area of New

A Motor Tractor ploughing Virgin Soil in Preparation for the forthcoming Cotton Crop. Maranoa District of Southern Queensland.

South Wales, which will eventually comprise some 200,000 acres of irrigable land—adequate provision has been made for drainage ; whenever new areas are opened up, or fresh canals are constructed, a thorough drainage system is also installed at the same time, thereby removing the danger of water-logging of the soil that has done so much damage to Egyptian cotton crops in the past.

American experience throws interesting light on the ill-effects that must eventually arise from the growing of cotton on the same land year after year, and it seems strange that it is only after a century's experience, when much of the soil of her cotton belt has become impoverished, and when the universal application of fertilisers has been rendered necessary, that the doctrine of diversification of crops is now being preached in the United States. Egypt has learnt this lesson, and, thanks to the British Government being able to exercise a certain amount of control over cotton growing in that country, only one-third of the cultivable area has been permitted to be devoted to the raising of cotton crops. Had America been able to exercise similar control over her cotton-growing states, the spread of the boll weevil would have been appreciably checked, and her one-time average yield of approximately 600 lb. of seed cotton per acre might well have been maintained.

Although improved machinery has greatly facilitated cultivation, Australia is as yet lamentably lacking in her methods of farming and in the thorough preparation of the soil previous to the planting of cotton : this is due to inexperience, and is a defect that time and the education of the grower alone can remedy.

In fairness to Australia it must be remembered that the bulk of the rural population of her cotton belt are graziers and dairymen rather than farmers. Genuine farmers are to be found mainly in the wheat-growing districts, where, by thorough and scientific methods of 'dry-farming' and fallowing, successful wheat crops have been raised on land possessing an annual rainfall of only twelve or fifteen inches. These improved methods of cultivation have to-day rendered it commercially possible for wheat to be raised in districts where twenty years ago it was considered quite impracticable to grow any crop, and that which has been proved to hold good in relation to the production of wheat may well apply in the future with regard to the growing of cotton.

Also modern machinery has so greatly facilitated the work

of cultivating the soil that crops may now be raised with less trouble and expense than was the case half a century ago.

Fluctuation in Values.—As has been indicated in the first part of this chapter, the disastrous fluctuations in the price of cotton brought about by the American Civil War were followed by a continuously low level. During the period 1867 to 1890 the average price was 6·1*d.* per lb. Then the large American crops caused production to outstrip consumption and from 1891 to 1902 cotton sold for an average price of only 3·85*d.* per lb.

From 1902 onwards, however, there has been a steady increase in values, and during the period 1903 to 1914 prices averaged 5·65*d.* per lb. During, and after, the European War they showed a big increase, as we find that from 1915 to 1922 the average value of Middling American at Liverpool was 14·38*d.* per lb. Since 1922 prices have not only been maintained but have further increased, and Australia is to-day given her second opportunity to become a cotton-producing country. She now enters the field at a very favourable moment, when high prices seem assured, and when there is a grave shortage of the finer varieties such as she can produce: if only she will profit by her past errors and by the experience that other countries have placed at her disposal she cannot fail to make a permanent success of cotton growing.

Cost of Production.—Provided that both climate and rainfall permit of successful cotton cultivation, then the determining factor as to whether or not Australia can be expected to produce cotton in commercial quantities on the expiration of the present Government guaranteed prices lies in the quality of her cotton and the cost of production. As it appears probable that no appreciable quantity of raw cotton will be consumed in Australia for many years to come, the cost of production should be calculated on the cost landed at Liverpool.

The following cost estimates are based, firstly, on data supplied by the Queensland Department of Agriculture; and secondly, on figures supplied by practical growers.

Government Figures. — The Department of Agriculture's costs of production figures, given under the headings of Farms Nos. 1, 2, 3 and 4, in the following table, were arrived at from actual costs on four average farms in the Dawson Valley (Queensland), and no allowance is made by the Department of Agriculture for interest on the capital value of the land. While the cost of ploughing appears to be above the average,

COST OF PRODUCTION BASED ON GOVERNMENT FIGURES

	Ploughing Twice.	Harrowing Twice.	Planting.	Horse Cultivating.	Chipping and Thinning.	Yield per acre in lb. of Seed Cotton.	Cost of Picking at $2d.$ per lb.	Bagging and Cartage.	Totals. £ s. d.	Cost of Production per lb. of Seed Cotton.
Farm No. 1 . . .	35/–	5/–	6/–	13/–	4/–	420	70/–	3/–	6 16 0	3·89*d.*
Farm No. 2 . . .	32/6	5/–	3/–	6/–	5/–	900	150/–	6/6	10 8 0	2·77*d.*
Farm No. 3 . . .	32/6	6/–	2/6	5/–	3/–	1000	166/8	7/6	11 3 2	2·68*d.*
Farm No. 4 . . .	35/–	5/–	3/6	9/–	5/–	1200	200/–	9/–	13 6 6	2·66*d.*
Averages .	33/9	5/3	3/9	8/3	4/3	880	146/8	6/6	10 8 5	3·00*d.*

Mean Cost of Production, 3·00*d.* per lb. for Seed Cotton, or 9·00*d.* per lb. for Lint.

COST OF PRODUCTION BASED ON GROWERS' FIGURES

Paddock.	First Ploughing.	Second Ploughing.	Four Harrowings at 1/9 per acre each.	Planting at 2/- per acre.	Three Cultivations at 3/9 per acre each.	Four Cultivations at 3/9 per acre each.	Thinning out at 11/- per acre and Chipping for Weeds.	Yield in lb. of Seed Cotton per acre.	Cost of Picking at $1\frac{1}{2}d.$ per lb.	Cost of Sacks at 6*d.* and cost of Packing at 6*d.* per Sack.	Haulage to Rail, 7 miles at 15/- per ton.	Interest on Value of Land (£15) at 6 %.	Interest on Value of Land (£7) at 6 %.	Total Cost.	Cost per lb. of Seed Cotton.
														£ *s.* *d.*	*d.*
No. 1 .	16/-	10/-	7/-	2/-	11/3	...	11/-	700	87/6	8/-	5/-	...	8/6	8 6 3	2·85
No. 2 .	16/-	10/-	7/-	2/-	...	15/-	31/-	1000	125/-	11/-	7/-	18/-	...	12 2 0	2·90
No. 3 .	16/-	10/-	7/-	2/-	11/3	...	11/-	1500	187/6	16/-	10/-	18/-	...	14 8 9	2·31
Averages	16/-	10/-	7/-	2/-	12/6		17/8	1067	133/4	11/8	7/4	14/10		11 12 4	2·68

Mean Cost of Production, 2·68*d.* per lb. for Seed Cotton, or 8·04*d.* per lb. for Lint.

insufficient allowance has been made for bagging and cartage from the farm to the railway; thus the excess in one case and the deficiency in the other about counteract one another. The allowance of 2*d*. per lb. for picking, however, is ridiculously high and more than outweighs the omitted cost of interest on the capital value of the land, leaving a margin in excess of the average cost of farm production; consequently the Government figures may be taken as the maximum average cost of production alongside rail.

Growers' Figures.—The table on p. 63 is compiled from figures obtained from the practical experience of Queensland growers. In each case the paddock comprised an area of ten acres under cotton; in some instances the soil was fairly free from weeds, and in others badly infested. The estimated value of the land in paddocks Nos. 2 and 3 (£15 per acre) is inclined to be on the high side, but otherwise the costs are very fair.

Paddock No. 1, ten acres of light forest upland soil on a well-drained slope, free from weeds, and with a good clay subsoil.

Paddock No. 2, ten acres of rich black alluvial creek soil, very badly infested with weeds—Bathurst Burr and Bell Vine (Morning Glory). Hence, an additional allowance of £1 per acre is made for chipping and weeding in this case, viz.: 31*s*. per acre, as against 11*s*. per acre for Paddocks Nos. 1 and 3.

Paddock No. 3, ten acres of rich black alluvial creek soil, fairly free from weeds.

Yields.—It will be noted that the average yield obtained from the Government figures works out at 880 lb., and from the growers' figures at 1067 lb. of seed cotton per acre; the latter is probably above the average, and the former is not far wrong. For proof of Australia's cotton-producing capabilities in a favourable season under natural rainfall we will quote a few of the high yields obtained in Queensland during the 1921–22 season:—

Grower's Name.	Address.	Net yield in lb. of Seed Cotton per acre.
P. Hansen	Gatton	1856
W. H. Drummond	Springsure	2047
W. L. Guy	North Rockhampton	2065
H. Frolisch	Ambrose	2168
G. Wright	Roadvale	2766
W. Grimsey	Boonah	2849

Average Australian Yields.—The following table has been compiled from figures published by the Queensland Department of Agriculture, and (1922) by the British Australian Cotton Association, Ltd. The year 1923 has purposely been omitted as the country experienced a phenomenal drought and all agricultural products suffered accordingly.

Year.	Acreage.	Yield of Seed Cotton in lb.	Average Yield per Acre (Seed Cotton).
1917	133	118,229	889
1918	203	166,458	820
1919	73	37,238	510
1920	166	57,065	344
1921	1967	940,125	478
1922	6000	3,887,280	648
Average yield of seed cotton per acre . . .			615 lb.

This indicated average yield of 615 lb. per acre is not, however, a true estimate of the country's capabilities, as in many instances, owing to lack of experience on the part of the growers, cotton has been cultivated on land unsuited to its requirements. Further, planting has often occurred during the wrong periods of the year and quite erroneous methods of cultivation and spacing have been adopted ; consequently, the average returns really obtainable per acre have not so far been realised, nor can one expect the optimum result to be arrived at until such time as the growers have acquired greater experience in the general cultivation of the crop.

One very noticeable feature of cotton in Australia is the prolific yield of the plants ; not only do Egyptian and American varieties produce a greater number of bolls per plant, but the size of the bolls and the number of segments, or loculi, are greater than those of similar strain plants when grown in the countries in which they originated.

Egyptian varieties in Egypt almost invariably produce bolls having three loculi ; yet the same strains when grown in suitable localities in Australia produce plants, 50 per cent. of which have bolls of four, instead of three, loculi.

The same holds good with American Upland varieties when grown in Australia, as about 50 per cent. of the plants carry bolls of five loculi, with occasional bolls of six, and even seven,

loculi. The reason for this increase is not apparent, and can only be attributed to climate and soil.

Thus, given good average cultivation together with normal climate and rainfall, the future Australian yield may be placed at approximately 800 lb. of seed cotton per acre.

FAIR AVERAGE ESTIMATE OF COST OF PRODUCTION

Yield 800 lb. of Seed Cotton per Acre

	£	s.	d.
Two ploughings	1	10	0
Three harrowings		6	6
Planting		3	0
Four cultivations		12	0
Chipping and thinning		10	0
Cost of picking, 800 lb. of seed cotton at 1½*d.* per lb.	5	0	0
Bagging and cartage		10	0
Interest at 6 per cent. on value of land (£7)		8	6
Total	£9	0	0

This production cost of £9 on 800 lb. of seed cotton per acre is equivalent to a cost of 2·70*d.* per lb. for seed cotton. For general simplicity, and so as to also allow a small margin for additional expenses or lower yields, we will increase this figure from 2·70*d.* to 2·75*d.* per lb. for seed cotton. As three pounds of seed cotton are about equal to one pound of lint, we arrive at the figure of 8·25*d.* per lb. for lint.

No allowance has been made for fertilisers, as these are unnecessary on virgin soil; but ginning costs have still to be added and, as Australia is not as yet a consumer of her own produce, it is further necessary to include freight and insurance on the cotton to Liverpool, together with handling charges, harbour dues and brokerage. The above expenses amount to 2·25*d.* per lb. of lint.

	Lint
Cost alongside railway in Australia	8·25*d.* per lb.
Ginning, freight, insurance, etc.	2·25*d.* ,,
Cost, landed at Liverpool	10·50*d.* per lb.

American Cost of Production.—In 1922 the United States Department of Agriculture stated that the lowest average cost of production was 17 cents, at Alabama, and the

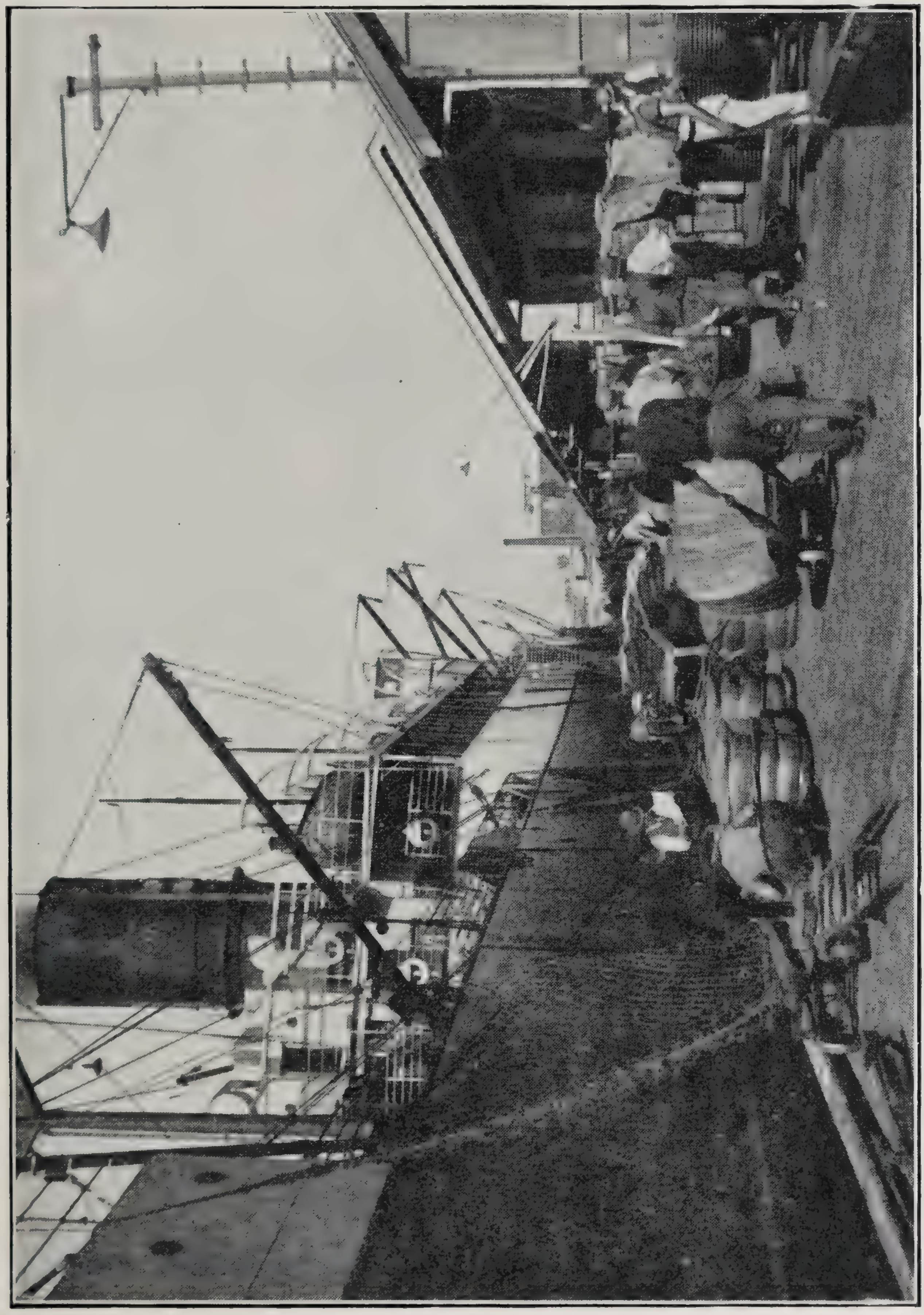
A mature Australian Cotton Boll, fully opened and ready for picking.

highest, at Georgia, 27 cents, whilst other authorities placed the average cost of production throughout the American cotton belt at 24·25 cents per lb. of lint. A mean of these figures gives us 22·75 cents, or approximately 11·37*d.* per lb. To this must be added the cost of freight, insurance, etc., from America to Liverpool, making the American cost of production on cotton landed at Liverpool 11·75*d.* per lb.

American versus Australian Costs of Production.—We see, therefore, that Australia can land her cotton at Liverpool for 10·25*d.* per lb., as against America's cost of 11·75*d.* But, before we can form any opinion of the competitive possibilities of the two countries, it is necessary to take three important facts into consideration—namely, the difference in seasons between the two hemispheres, the grade, and the comparative qualities of the cottons produced.

Freight on cotton shipped from America to Liverpool is very much less than from Australia to Liverpool, but the difference between the seasons of the Northern and Southern hemispheres gives to Australia an advantage that more than compensates for her heavier freight expenses. As the Australian crop ripens some six months after the American crop, it arrives in the United Kingdom when the English market is more or less depleted of cotton, and consequently benefits by the 'carrying charges' that have to be paid on American cotton. The bulk of the exported American crop reaches Liverpool during the months of September, October, November, and December. Consequently, English spinners, whose mills are working regularly throughout the year, are compelled to buy the greater portion of their year's requirements early in those months, and to carry their necessary stock until September or October of the following year, when new crop American cotton is again available. If they buy for future delivery it amounts to the same thing, as in this case the supplier will quote them a price that includes his carrying charges.

Australia being situated in the Southern hemisphere, her crop matures and is ginned during April, May and June, reaching Liverpool in June, July and August, when 'spot' cotton is scarce on that market; consequently, it finds a ready sale. Thus, as the Australian cotton obtains the advantage of these carrying charges, the difference between the low American and the high Australian freights is about neutralised.



Shipping Cotton for London on s.s. 'Westmorland,' Birts Wharf, Brisbane, July 1921.

Owing to the absence of insect pests in Australia the crop, in spite of the inexperience of the pickers, contains only a small proportion of stained or diseased cotton, and the average grade is about equal to 'good Middling' American—*i.e.* to one of the rather higher of the American categories.

Of the quality of Australian cotton the fairest test is to be found in the price that it has realised when sold on the open market at Liverpool. The Australian crop of the last two seasons has fetched an average price of approximately 2*d.* per lb. above the quotations for Middling American on the Liverpool market, and seeing that the present Australian cotton is the product of impure seed, and is consequently inclined to be irregular in length of staple, the fact that it should realise this premium over American cotton speaks well for the length, strength and fineness of the Australian product.

Efforts have been made during the last couple of years to determine which is the variety most suited to Australian conditions, and with this end in view, numerous varieties have been roughly tested throughout different localities under normal field conditions. Of these varieties, Durango, a pure strain of long-stapled American Upland, has given the best results, both as regards yield and quality, and the few bales of Durango shipped to Liverpool have been sold for an average price of 3½*d.* per lb. above Middling American, or, roughly speaking, this variety has realised the same price as Egyptian cotton. Durango appears to be in every way so well suited to Australian conditions and has given such excellent results, that in two years' time it will probably be the standard cotton of Australia and, when once it is universally cultivated, the Australian crop should obtain a premium of approximately 3½*d.* per lb. over Middling American. This premium may be utilised as a margin with which to meet foreign competition or a fall in prices. Thus, even should the value of Middling American at Liverpool drop to 7*d.* per lb., Australia should still be able to produce cotton as a paying proposition; for if the premium of 3½*d.* per lb. for the good quality of Durango be added to the above figure of 7*d.* per lb. for Middling American, we arrive at 10½*d.* per lb., or the present Australian cost of production.

From 1915 to the present date the price of Middling American has averaged more than 14·38*d.* per lb., and it is worthy of note that before the War, *i.e.* from 1908 to 1914, when the average crop was 13,750,000 bales, the mean price

in the United Kingdom was 6·78*d.* per lb. Since that period there has been a decrease in production in addition to the vast increase in cost ; judging, therefore, by the present state of affairs and future prospects, there does not appear to be any likelihood of Middling American being quoted at 7*d.* per lb. for many years to come.

All those causes that were in the past responsible for Australia's lack of success are capable of remedy, and to-day the greatest obstacles have been overcome ; for, thanks to the energetic action of the part of the Queensland and New South Wales Governments the practice of ratooning cotton has been prohibited and all plants have to be uprooted at the end of each season.

Through the initiative and business enterprise of the British Australian Cotton Association numerous modern ginning factories and two cotton-seed oil mills have been erected for dealing with the crop, whilst thorough arrangements have been made for its marketing in England. The Australian cotton industry of to-day stands on firm foundations and a further rapid increase of cultivation may be looked for in the near future.

Briefly, Australia may be expected to produce cotton successfully and in increasing quantities whilst the price of Middling American at Liverpool remains *at or above 7d. per lb.*, but should values fall to below this figure, then her agricultural activities will probably be diverted into other and more profitable channels.

CHAPTER V

NEW SOUTH WALES—CLIMATE AND RAINFALL

Controlling factors—Ideal cotton-growing conditions—Area of Australia—Estimated area capable of producing cotton—Seasons—Uniform climate—Rainfall—Monsoonal rains—Texas, U.S.A., compared with New South Wales—Texas, U.S.A.—The North-Western Districts of New South Wales—Dubbo, Central Western Slopes—Casino, Northern Coastal District—Murrumbidgee Irrigation Area—Map of the cotton-growing areas of New South Wales—Coastal belt—Assured inland districts—Doubtful districts—Unsuitable districts.

Controlling Factors.—In endeavouring to arrive at the most advantageous dates for the sowing and the picking of cotton in new countries where there is little or no past experience to guide us, calculations should be based on the fundamental factors of the rainfall and the temperature of the country or districts under consideration; as, if these controlling climatic factors be given due attention, one will, in the great majority of cases, arrive at the approximately correct dates for each locality. Dates deduced from a study of climatology should be adhered to until actual experience in the field furnishes proof of error. Undoubtedly, local conditions in certain areas may necessitate minor variations from the planting dates obtained through a study of rainfall and temperature, but, until the necessary field experience is available, one is justified in sowing the seeds at that period of the year which is indicated by the latter as most suited to the subsequent growth of the plants in normal seasons.

Ideal Cotton-Growing Conditions.—Ideal conditions in regard to temperature and rainfall would consist of: a steadily rising temperature for a month or six weeks previous to sowing and until the period of maturity when the maximum daily opening of the bolls is attained; of good rains during the planting season so as to ensure a thorough germination of the seeds, immediately followed by about a month of comparatively dry weather. The rains should then become more frequent and increase in volume till immediately previous to

the plants' point of maturity, when a prolonged period of dry, warm weather should occur and continue throughout the picking season.

If soaking rains are experienced directly after sowing the seeds are liable to rot in the ground instead of germinating, while if the rains are too frequent during the first few weeks following germination, the tendency is for the plant's root system to throw out excessive surface laterals with the consequent shortening of the tap root; whereas, if a temporary dry period follows after good rains at planting time, the formation of surface lateral roots is checked and the downward growth of the tap root in search of water is accentuated, thereby providing a deep seated root system that enables the plant to obtain sufficient moisture from the sub-soil should a period of drought be experienced during the latter stages of development.

Ideal conditions, similar to those just mentioned, may only be obtained under irrigation in suitable climates, such as Egypt, the Anglo-Egyptian Soudan, parts of California and India, and are very rarely available when one has to depend entirely on natural rainfall. It therefore follows that in new cotton growing countries, after due allowance has been made for temperature, the date of planting should be fixed so as to ensure that the crop shall, during normal seasons, have both an ample rainfall during its growth and a dry picking period. Thus, before any attempt is made to determine such dates, even approximately, one must first of all fully investigate the meteorological conditions of the country under consideration.

Area of Australia.—Australia is about three-quarters the size of Europe, and is slightly larger than the United States of America. The total area of the Commonwealth, including Tasmania, is 2,974,581 square miles. The continent extends on both sides of the Tropic of Capricorn, from 10° to 45° S. latitude; 1,149,320 square miles lie within the tropical zone, and 1,020,720 square miles lie within the temperate zone, so that as far as temperature is concerned there are approximately 2,000,000 square miles capable of growing cotton. Australia is characterised by a very uniform coastline and a lower average elevation than that of any other continent, and as a whole has a generally temperate climate.

On the other hand, there is but a scanty rainfall in many parts of the continent, and the area capable of growing cotton is approximately limited to those districts that possess an

annual fall of 20 in. or upwards, the bulk of which precipitation must occur during the summer months.

Estimated Area Capable of Producing Cotton.—If due allowance is made for temperature, rainfall and the season of the year during which such rainfall occurs, it is possible to arrive at a very approximate estimate of the area of land in Australia that should be capable of producing cotton. The total areas shown in the following table were obtained from statistics published in the 'Official Year Book of the Commonwealth of Australia,' and the approximate areas of cotton growing lands are based on the map illustrated on the frontispiece of this book :—

State.	Total Area in Square Miles.	Estimated Area in Square Miles capable of Growing Cotton.
Queensland . . .	670,500	300,000
New South Wales . .	309,432	75,000
Western Australia . .	975,920	90,000
Northern Territory . .	523,620	120,000
Victoria	87,884	1,000
South Australia . .	380,070	1,000
All States . . .	2,947,426 [1]	587,000

[1] Exclusive of Tasmania and the Federal Territory.

This figure of 587,000 square miles is equivalent to 375,680,000 acres, or, roughly, Australia possesses a considerably greater area of land endowed with the necessary cotton growing climate and rainfall than does the United States of America, as the area of the American cotton belt is estimated at 300,000,000 acres by the U.S.A. Department of Agriculture.

Seasons.—The annual southern limit of the sun is reached on or about December 22, but in consequence of a slight lag in heating effect, January is generally the hottest, and July the coldest, month in Australia. Therefore the seasons of the year may be divided as follows :—

Winter . .	June, July and August.
Spring . .	September, October and November.
Summer . .	December, January and February.
Autumn . .	March, April and May.

As Australia extends over some 35° of latitude, there is naturally a very great difference between the extremes of the continent: Darwin in the north having a tropical climate resembling that of Trinidad, while Tasmania has a cool, moist climate similar to that of England.

As the northern areas come under monsoonal and equatorial conditions, the four seasons are not well defined, and in the north of the continent the year may be divided into two seasons : the wet season and the dry season.

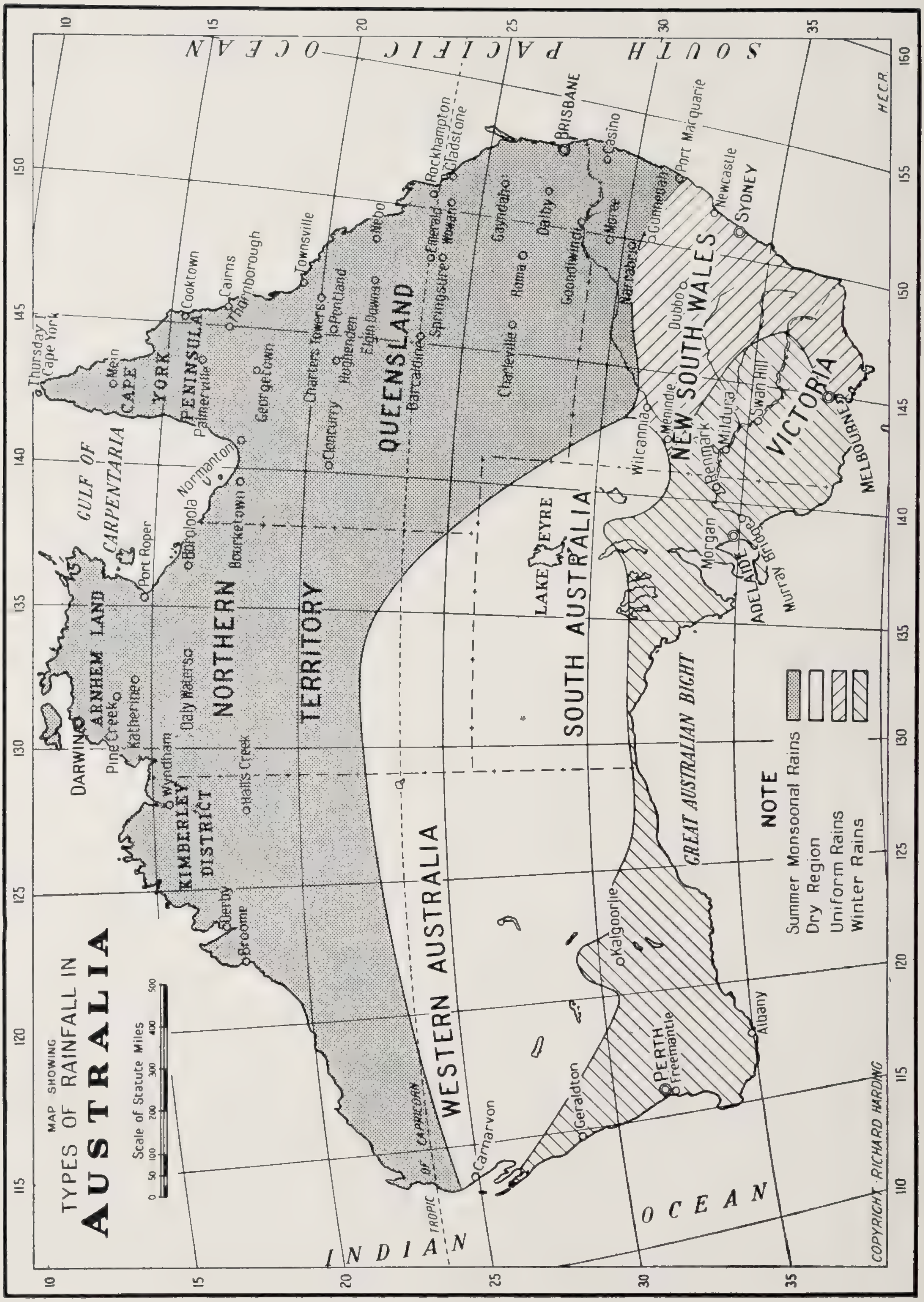
As one gets further south and touch is lost with the monsoon, the four seasons gradually become more pronounced ; but even so, definite wet and dry periods are still noticeable throughout the greater portion of the year in the southern areas.

Uniform Climate.—Taking Australia as a whole, it will be found that the climate is very uniform and that the extremes of temperature annually, seasonally and daily, are not as great as those of any of the other continents ; while the mean prevailing temperatures are, in almost all cases, more uniform than for other continental areas of the world in corresponding latitudes. This absence of extremes is clearly noticeable in the following diagrams, and is probably due to the even altitude and the insularity of the continent.

Rainfall.—The rainfall is greatest in proximity to the sea coast, but unfortunately it does not penetrate for the same distance inland around the continent, the northern and eastern sections being comparatively well watered, while the southern and western areas suffer from lack of rain. The central district, owing to its even altitude and the absence of any mountain range on which moisture might condense, is phenomenally dry, and has an average annual rainfall of about 5 ins. Over the 2,948,366 square miles of Australia (Tasmania is excluded in the above figure) the rainfall is distributed as follows :—

1,105,452	sq. miles	receive	less than	10	ins.	per annum.[1]
592,459	,,	,,	from	10 to 15	,,	,,
350,035	,,	,,	,,	15 to 20	,,	,,
522,999	,,	,,	,,	20 to 30	,,	,,
197,033	,,	,,	,,	30 to 40	,,	,,
180,388	,,	,,	over	40	,,	,,

[1] Figures obtained from the 'Official Year Book of the Commonwealth of Australia.'


MAP SHOWING
TYPES OF RAINFALL IN
AUSTRALIA
Scale of Statute Miles
NOTE
Summer Monsoonal Rains
Dry Region
Uniform Rains
Winter Rains
WESTERN AUSTRALIA
NORTHERN TERRITORY
QUEENSLAND
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
GULF OF CARPENTARIA
GREAT AUSTRALIAN BIGHT
LAKE EYRE
ARNHEM LAND
KIMBERLEY DISTRICT
CAPE YORK PENINSULA
INDIAN OCEAN
SOUTH PACIFIC OCEAN
TROPIC OF CAPRICORN
DARWIN
BRISBANE
SYDNEY
MELBOURNE
ADELAIDE
PERTH
COPYRIGHT RICHARD HARDING

Monsoonal Rains—As rainfall is only being studied herein from the view-point of how it affects cotton, our attention may be mainly confined to the monsoonal rains, as these cover almost the entire Australian cotton belt. These rains are usually fairly dependable and enable one to foretell with a fair degree of accuracy the probable dates of their commencement and cessation, together with the approximate amount of moisture they will precipitate.

The monsoonal region embraces almost the whole of that portion of Australia that is situated to the northward of the Tropic of Capricorn, but on the eastern coast the monsoonal rains extend as far as Port Macquarie, in New South Wales, lat. 31° 25′ S., which may be said to mark their southern extremity although the faintest traces are just discernible at Dubbo in the same State, situated 177 miles inland from the coast, in Lat. 32° 18′ S.

The monsoonal rains commence in the spring, in the extreme north of the continent during the very end of the month of September; by the middle of October their effects are usually felt over the entire north-eastern coast; and by the beginning of November they have extended as far south as the border between Queensland and New South Wales. From then onwards, the rains increase in intensity, the maximum precipitation being attained at midsummer, during the months of January and February. March shows a decrease, while by the end of April the rains have receded and the dry weather period has set in.

The following graph diagrams contained in this chapter show the average monthly rainfalls and mean temperatures of representative areas in the cotton belt of New South Wales, and all have been compiled from official or authentic sources. American figures have been obtained from 'Shepperson's Cotton Facts,' whilst Australian data have been taken from official charts, tables of statistics, or publications issued by the Commonwealth Meteorological Bureau. The author is greatly indebted to the officials of this institution for the valuable help they have rendered and for the readiness with which they have supplied detailed data relating to any specific place or locality that is not included in their general publications.

Only in exceptional instances do the diagrams represent the average of records extending over less than seventeen years; in fact, the great majority of Australian figures

have been obtained from records covering a period of thirty years or upwards.

Texas, U.S.A., compared with New South Wales.—Diagram No. 1 draws comparisons between the climatic conditions of the two hemispheres, namely, between Texas, U.S.A., and certain districts of New South Wales. The selection of Texas for comparison with the above-named State of Australia, has been made deliberately, as both are situated in approximately the same latitudes on either side of the equator ; and because of the similarity between Texas cotton and the cotton produced by New South Wales, both being above Middling American in strength, length, quality and price. Further, as Texas annually produces some 2,500,000 bales of cotton, there can be no question as to the suitability of that State for cotton cultivation, and if other parts of the world possess a similar climate and rainfall they should be able to produce cotton with equal success.

Texas is approximately confined between the 29° and 35° N. latitude. The Central Western and the North-Western Slopes, together with that portion of the North-Western Plains of New South Wales, which possesses the requisite rainfall, are confined between the 29° and 33° S. latitude. The average annual rainfall in Texas amounts to 30·3 in., and the mean annual temperature to 66·5° F. On the North-Western Slopes district of New South Wales, the average annual rainfall (*i.e.* the average of all recording stations in that area) amounts to 27·6 in., and the mean annual temperature to 65·9° F.

In order to facilitate the comparison of climatic conditions in these districts situated on either side of the equator, the seasons of the year in the Northern and Southern hemispheres have been made to synchronise in Diagram No. 1. As January is the coldest month in the Northern and July is the coldest month in the Southern hemisphere, these months have been brought directly opposite to one another. Thus, the months, the monthly mean averages of rainfall and temperature shown at the top of diagram No. 1, represent those of Texas in the Northern hemisphere, whilst those shown at the bottom of the diagram represent New South Wales in the Southern hemisphere.

The coincidence that exists between the mean temperature-curves is very noticeable and would seem to justify the come parison of the month of January in north latitude with the

month of July in south latitude ; additional proof being provided by the manner in which the dates of the commencement and cessation of frosts in corresponding latitudes in both hemispheres also synchronise.

Texas, U.S.A.—Figures relating to Texas comprise the average of monthly records taken over a period of seventeen years. In Texas the cotton season roughly occupies some eight and a half months, from the earliest sowing to the latest picking dates, as against about eight months for New South Wales. The heaviest rains in Texas occur either during or immediately after the sowing period, and thereby ensure successful germination of the cotton seeds. As good rains continue until the middle of June, no difficulty should be encountered by the Texas crop in making a good start ; but from the end of May until the end of July the rainfall steadily decreases. Thus, in Texas, the crop receives least rain during June and July—the critical fruiting and bolling period—when the strain upon the plants is greatest and they have the most need of moisture. On the other hand, during the main picking months of August, September and October, when no rain is required, there is an appreciable increase in precipitation.

The North-Western Districts of New South Wales.—The New South Wales data used in the compilation of Diagram No. 1 have been obtained from Commonwealth Meteorological records. Figures relating to rainfall represent the averages of all meteorological recording stations situated on the North-Western Slopes and consist of the average of records extending over a period of thirty-six years. The districts of New South Wales under consideration comprise the North-Western Slopes, the eastern portion of the North-Western Plains, and the great majority of the area of the Central Western Slopes. The North-Western Plains and the North-Western Slopes are situated adjacent to one another in similar latitudes ; the Central Western Slopes lie almost directly to the southward of the North-Western Plains. These three districts are located on the inland slopes of the coastal mountain range and possess very similar climatic conditions, if due allowance be made for the slight difference in temperature and monsoonal rainfall due to the fact that the North-Western Plains and the North-Western Slopes are slightly nearer to the equator than the Central Western Slopes. Although the town of Narrabri is situated on the eastern border of the North-Western Plains, and is not, therefore, actually within the North-Western Slopes district, it

DIAGRAM No. 1

TEXAS, U.S.A. COMPARED WITH THE NORTH WESTERN SLOPES OF N.S.W.

Mean Annual Rainfall Texas - 30·3" .... Mean Annual Rainfall N.W. Slopes - 27·6" ———

Mean Annual Temperature Texas - 66·5° ———— Mean Annual Temperature N.W. Slopes - 65·9° ————

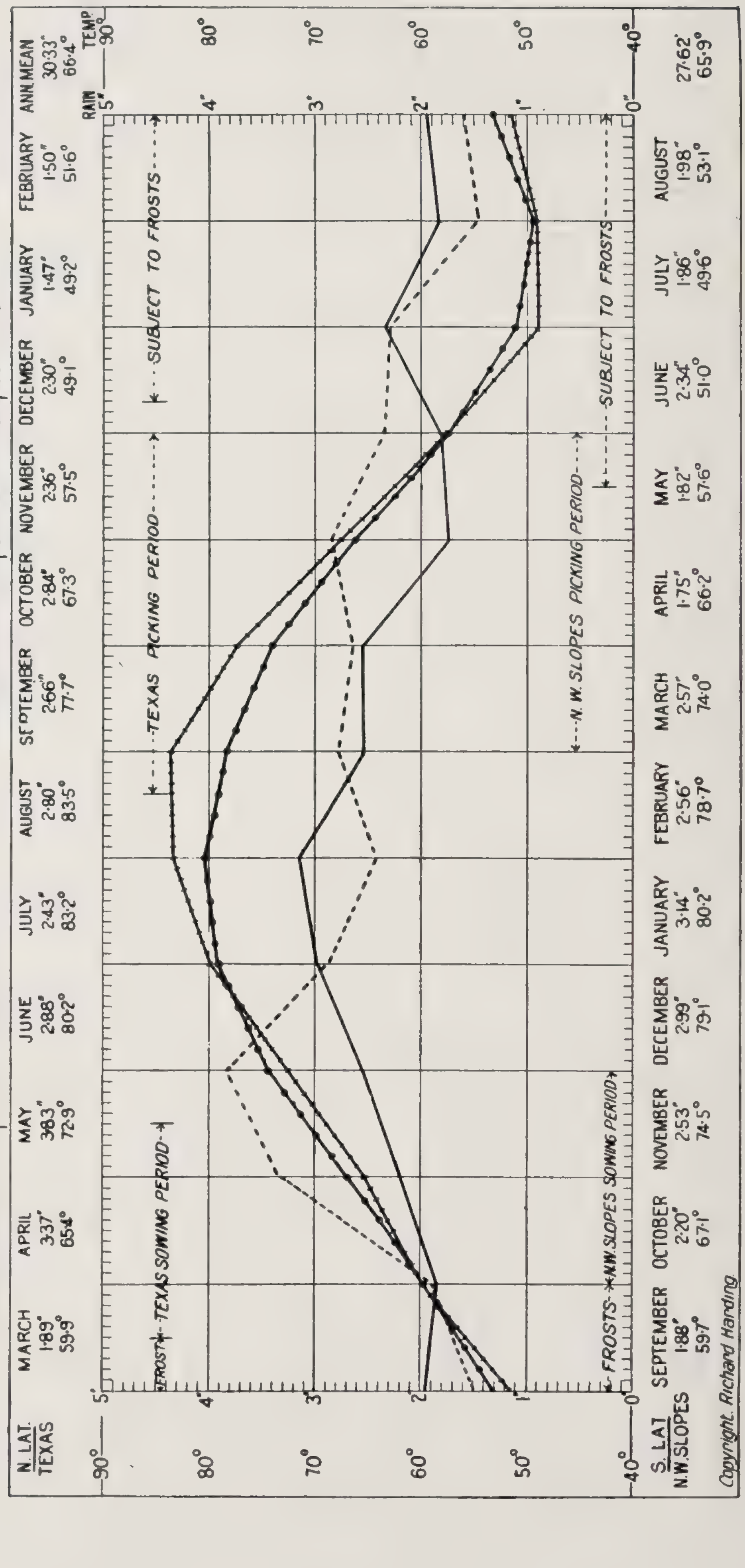


DIAGRAM No. 1.—TEXAS, U.S.A.—NORTH-WESTERN SLOPES OF NEW SOUTH WALES

New South Wales—Temperature

N.S.W. Temperature.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Gunnedah. Max.	10	94·4°	92·5°	87·7°	80·0°	69·7°	62·1°	61·6°	66·0°	74·0°	81·2°	88·6°	94·0°	79·3°
,, Min.	10	62·6°	62·6°	58·4°	50·5°	44·5°	37·9°	37·2°	39·0°	45·1°	51·5°	59·4°	62·3°	50·9°
,, Mean	10	78·5°	77·5°	73·0°	65·2°	57·1°	50·0°	49·4°	52·5°	59·5°	66·3°	74·0°	78·1°	65·1°
Narrabri. Max.	46	97·1°	94·3°	89·1°	81·3°	71·2°	63·9°	62·6°	67·6°	74·4°	82·9°	90·4°	95·6°	80·8°
,, Min.	46	66·7°	65·5°	61·2°	53·1°	45·1°	40·1°	37·1°	40·0°	45·5°	52·9°	59·8°	64·7°	52·6°
,, Mean	46	81·9°	79·9°	75·1°	67·2°	58·1°	52·0°	49·8°	53·8°	59·9°	67·9°	75·1°	80·1°	66·7°
N.S.W. Average Mean Temp.	28	80·2°	78·7°	74·0°	66·2°	57·6°	51·0°	49·6°	53·1°	59·7°	67·1°	74·5°	79·1°	65·9°

New South Wales—Rainfall

N.S.W. Rainfall.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Average, N.W. Slopes (all Stations)	36	3·14″	2·56″	2·57″	1·75″	1·82″	2·34″	1·86″	1·98″	1·88″	2·20″	2·53″	2·99″	27·62″

Texas, U.S.A.—Temperature and Rainfall

Texas, U.S.A.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mean Temperature	17	49·2°	51·6°	59·9°	65·4°	72·9°	80·2°	83·2°	83·5°	77·7°	67·3°	57·5°	49·1°	66·3°
Average Rainfall	17	1·47″	1·50″	1·89″	3·37″	3·83″	2·88″	2·43″	2·80″	2·66″	2·84″	2·36″	2·30″	30·33″

nevertheless forms the approximate central point of the three districts under review, and data relating to temperature have been mainly based on this town, as its meteorological records extend over a period of forty-six years, as against only the ten year records that are available for the town of Gunnedah. The plotted temperature curve for the North-Western Slopes of New South Wales has therefore been computed from the mean monthly figures for Narrabri and Gunnedah.

Although the monsoonal rains of the Australian cotton belt are fairly dependable, there nevertheless occur years when the weather breaks before, or after, the average date ; and when considering the cultivation of cotton under natural rainfall conditions due allowance should be made for possible variations in the date of the commencement of these summer rains. Thus growers may be justified in planting previous to the average normal date of the breaking of the monsoon if their district experiences good early rains ; or in withholding planting until after the average date—and until such time as they receive sufficient rain to ensure thorough germination—if the monsoon be backward. Whilst admitting that a certain amount of license and discretion in this respect is both justifiable and desirable, planting should as nearly as possible coincide with the optimum date indicated by a study of the general temperature and rainfall of the country.

An inspection of Diagram No. 1 shows that if Upland varieties of cotton are planted on the North Western Districts of New South Wales during the months of October and November, the sowing period will not only escape the risk of frost but will also closely coincide with the seasonal period arrived at by Texas, U.S.A., after over a century's practical experience of cotton growing. Further, the resultant crop must receive the maximum benefit from existing climatic conditions ; for, in addition to a warm seed-bed, there is a steadily rising temperature and an increasing rainfall during the months of November, December and January.

January is the month of fruiting when the plants have the greatest need of moisture, and Nature meets their requirements, for January is the month of greatest rainfall. In February the rainfall commences to decrease and continues to diminish throughout the later stages of the plants' development ; this decrease in rainfall from February onwards will not only tend to check the formation of new vegetative growth, but will also help to ripen off the crop during the warm months

RICH ALLUVIAL FLATS SUITABLE FOR COTTON GROWING, NEAR TEXAS, ON THE NEW SOUTH WALES AND QUEENSLAND BORDER.

of February and March. The minimum monthly precipitation occurs during April, when the crop should be ready for picking if planting has occurred during October.

Briefly summarised, Diagram No. 1 shows that if Upland cotton is planted round about *October 31,* on the North Western Slopes, the North Western Plains and the Northern half of the Central Western Slopes of New South Wales, the crop in normal seasons will receive an increasing rainfall during the first three months of its growth, a slightly decreasing rainfall during the fourth and fifth months of its existence, and that picking will therefore occur during April and May, which are the two driest months of the year in that part of the State.

If the crop is planted previous to October 1 it is liable to be damaged or totally destroyed by spring frosts, while should it escape these frosts, then such very early planting must result in it ripening towards the end of the summer and during the period of comparatively heavy rainfall.

If planting is delayed until after November 30, then the ripening of the crop will be interfered with by the cold weather of the late autumn and early winter months.

Dubbo, Central Western Slopes.—Dubbo is an inland town 177 miles from the sea coast, in latitude 32° 18′ S., longitude 148° 35′ E., at an altitude of 863 ft., and is situated in the southern portion of the Central Western Slopes district of New South Wales. Dubbo is of interest for two reasons : firstly, because it approximately marks the southern limit of those districts of New South Wales that are climatically especially suited for cotton production under natural rainfall conditions ; and secondly, because it lies in the area of uniform rains and has the most evenly distributed rainfall of any meteorological recording station in Australia.

The average annual rainfall, taken from records extending over 41 years, amounts to 22·19 in., but as the precipitation is so uniform throughout the year, rainfall does not really enter into calculations for determining the optimum period for the sowing of cotton, and the controlling factors in this instance are to be found in temperature and good cultivation. If the maximum results are to be obtained from cotton in this area it would appear necessary to employ thorough methods of dry-farming, so as to conserve all possible moisture in the soil, by allowing the land to lie fallow for at least some months previous to planting.

The mean annual temperature at Dubbo, obtained from

records covering a period of forty-eight years, is 63·4°, and, as frosts may be experienced during four and a half months of the year, the time of planting and the varieties that may be cultivated are directly controlled by temperature. Consequently, only quick maturing varieties, such as American Upland, would appear to be suited to this locality.

Diagram No. 2 indicates that planting should take place as early as possible in the spring, when danger from frost is past, thereby enabling full advantage to be made of a rising temperature during the period of growth, and allowing sufficient time for the crop to mature and be picked before the autumn frosts commence. Little is to be gained by planting *too* early in the spring whilst the soil is still cold, as, even if successful germination is obtained, there is always the risk that a late spring frost may so damage the seedlings on their appearance above the ground as to necessitate a complete re-sowing. Yet, where the growing season is comparatively short early planting is necessary, and a legitimate risk has to be taken with regard to late spring frosts. It therefore appears as if the period *October 1 to 10* would prove to be the optimum planting period for the Dubbo District.

If planting occurs previous to October 1 the young plants on appearing above the ground run grave risk of destruction by frost ; if after November 15 the autumn frosts will, in all probability, interfere with the ripening of the crop.

Casino, Northern Coastal District.—The State of New South Wales, together with most of the State of Queensland, may roughly be divided into two very distinct climatic areas separated from one another by the coastal mountain range that varies in altitude from 2000 to over 3000 feet, and the marked climatic difference that exists between places in the same latitude depends almost entirely on whether they are situated on the inland or the seaward side of this range. Speaking in very broad terms, it may be said that the inland districts have the lower yet more even rainfall, but experience the greater range and fluctuation of temperatures. The coastal areas possess very even temperatures, but are often subjected to violent fluctuations in rainfall, as, although the periods of the year during which the rains occur are well defined, the precipitation is at times torrential in intensity and very local in character. These big differences in rainfall between coastal localities—which may only be separated from one another by a score or so of miles—render it somewhat difficult

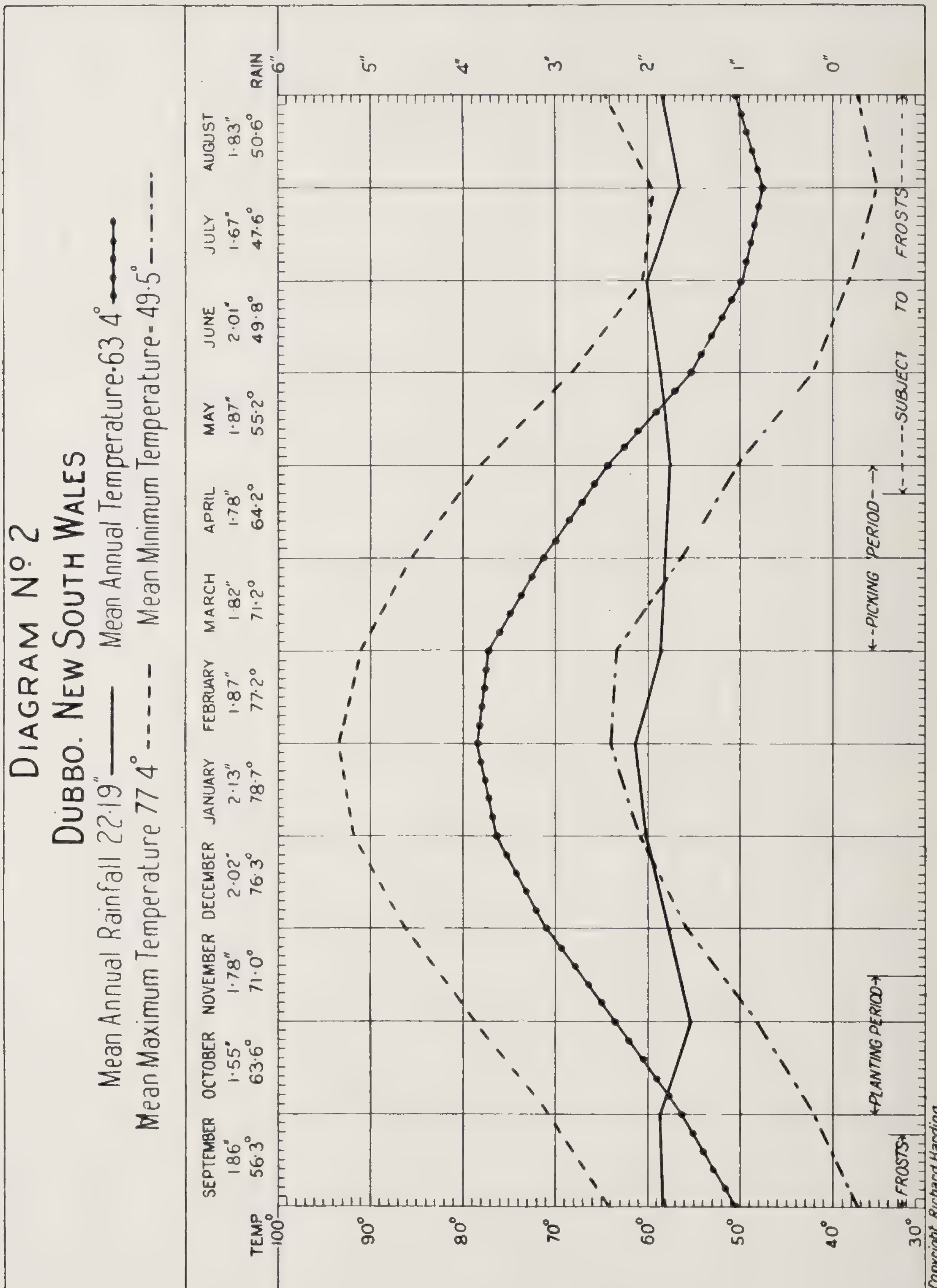


DIAGRAM No. 2
DUBBO. NEW SOUTH WALES
Mean Annual Rainfall 22·19"
Mean Annual Temperature·63·4°
Mean Maximum Temperature 77·4°
Mean Minimum Temperature - 49·5°
SEPTEMBER 1·86" 56·3°
OCTOBER 1·55" 63·6°
NOVEMBER 1·78" 71·0°
DECEMBER 2·02" 76·3°
JANUARY 2·13" 78·7°
FEBRUARY 1·87" 77·2°
MARCH 1·82" 71·2°
APRIL 1·78" 64·2°
MAY 1·87" 55·2°
JUNE 2·01" 49·8°
JULY 1·67" 47·6°
AUGUST 1·83" 50·6°
RAIN
6"
5"
4"
3"
2"
1"
0"
TEMP
100°
90°
80°
70°
60°
50°
40°
30°
FROSTS
PLANTING PERIOD
PICKING PERIOD
SUBJECT TO FROSTS
Copyright Richard Harding

DIAGRAM No. 2.—DUBBO, CENTRAL WESTERN SLOPES OF NEW SOUTH WALES

Temperature

Central Western Slopes District of New South Wales.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Dubbo Max. Temp. . .	48	93·4°	91·2°	85·8°	78·0°	68·2°	60·9°	59·7°	64·1°	70·6°	78·9°	86·3°	91·8°	77·4°
,, Min. Temp. . .	48	64·0°	63·3°	56·5°	50·3°	42·3°	38·6°	35·5°	37·1°	42·0°	48·2°	55·6°	60·8°	49·5°
Average Mean Temp. .	48	78·7°	77·2°	71·2°	64·2°	55·2°	49·8°	47·6°	50·6°	56·3°	63·6°	71·0°	76·3°	63·4°

Rainfall

Dubbo, N.S.W.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Average Rainfall . .	41	2·13″	1·87″	1·82″	1·78″	1·87″	2·01″	1·67″	1·83″	1·86″	1·55″	1·78″	2·02″	22·19″

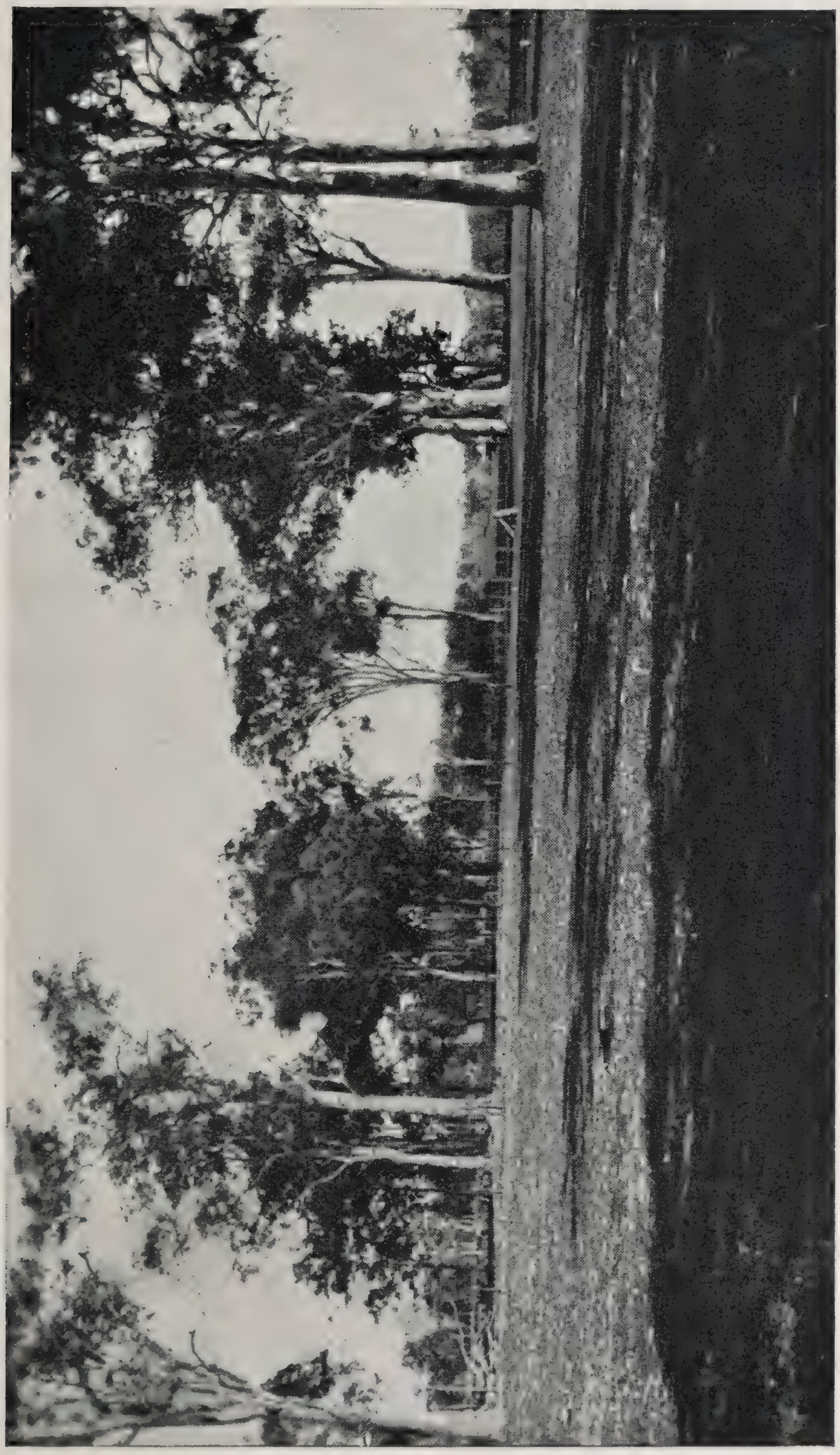
to illustrate the average rainfall of any large area of land; and although Diagram No. 3, Casino, may be taken as fairly representative for the Northern Coastal Districts of New South Wales, there are many towns situated on the foothills, or on the sea-coast, that experience an appreciably heavier or lighter rainfall due to purely local conditions. Owing to the proximity of these coastal districts to the sea, the temperature does not vary between one locality and another in the same manner as the rainfall; consequently the temperature data shown in Diagram No. 3 may be taken as typical for the coastal belt of Northern New South Wales.

Casino is situated in lat. 28° 50′ S., long. 153° 0′ E., at an altitude of 82 feet above mean sea level, and 28 miles distant from the sea. The average annual rainfall, procured from Government records extending over a period of forty-eight years, amounts to 43·52″, and is of the monsoonal type. Unfortunately, temperature records have only been kept for the last eleven years, but the average annual temperature for this period is 67·6° F.

As on the coastal belt lying to the north of Newcastle frosts are usually only experienced during the mid-winter month of July, this district is favoured with a long growing season, which, coupled with the warm, humid summer temperature free from violent daily or monthly fluctuations, should permit of the successful cultivation of both slow maturing Sea Island and fine long-stapled American Upland varieties. The rainfall throughout all periods of the year is sufficient to ensure germination, but care must be exercised in the choice of sowing dates for different varieties, so as to avoid the ripening of the crop during the peak rainfall months of February and March.

The plotted data shown in Diagram No. 3 point to Egyptian or Sea Island varieties being sown during the period September 15 to October 31, and indicates *September 30* as the optimum planting date for these varieties. Owing to the shorter growing period required for American Upland varieties they should not be sown until the month of November, and *November 15* would appear to be the most favourable date for these types.

If the respective varieties before mentioned are planted previous to the dates suggested, the rainfall in normal seasons must interfere with the picking, whilst if sowing occurs after the dates named, the cool weather in the end of May and



Prospective Cotton Land, near Goomeri.

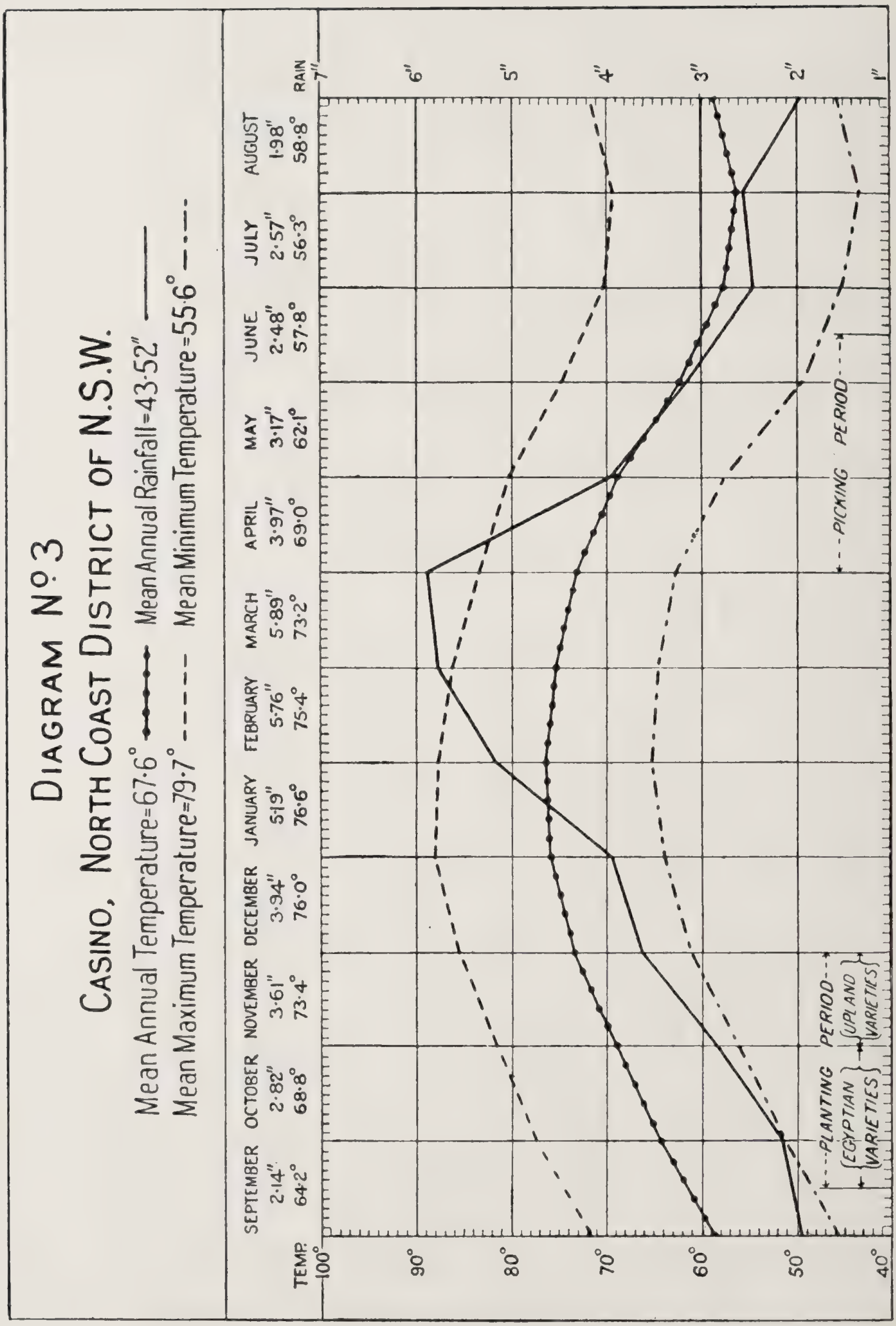


DIAGRAM No. 3

CASINO, NORTH COAST DISTRICT OF N.S.W.

Mean Annual Temperature = 67·6° —•—•— Mean Annual Rainfall = 43·52" ———
Mean Maximum Temperature = 79·7° - - - - - Mean Minimum Temperature = 55·6° —·—·—

Copyright Richard Harding

DATA RELATING TO DIAGRAM No. 3, CASINO

Temperature

Temperature.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mean Maximum . .	11	87·8°	86·1°	83·4°	80·3°	74·7	70·4°	69·4°	71·8°	77·3°	81·5°	85·4°	88·0°	79·7°
Mean Minimum . .	11	65·3°	64·8°	62·9°	57·7°	49·5°	45·3°	43·2°	45·7°	51·2°	56·1°	61·3°	64·0°	55·6°
Mean Average . . .	11	76·6°	75·4°	73·2°	69·0°	62·1°	57·8°	56·3°	58·8°	64·2°	68·8°	73·4°	76·0°	67·6°

Rainfall

Rainfall.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mean Average . . .	48	5·19″	5·76″	5·89″	3·97″	3·17″	2·48″	2·57″	1·98″	2·14″	2·82″	3·61″	3·94″	43·52″

throughout the winter months of June and July will prevent the ripening of the crop.

The coastal districts of New South Wales, with their favourable temperature and assured rains, should undoubtedly be able to produce successfully the finer varieties of cotton, but they would appear to be slightly handicapped by an excess of rainfall that continues for one month longer than is really desirable. The situation, although very favourable, would be improved if the rains diminished at the end of February instead of at the end of March.

Murrumbidgee Irrigation Area of New South Wales.—The Murrumbidgee Irrigation Area is approximately confined between latitude 34° and 35° S., longitude 145° 30′ and 146° 30′ E., at a distance of some 225 miles inland from the Pacific coast. This district is situated on the border of the uniform and the winter rain belts, but, as the greatest precipitation occurs during the winter months, it has to rely almost entirely on irrigation throughout the summer.

The necessary water is provided by the Burrinjuck Dam (originally known as Barren Jack), which was completed in 1918 at a cost, inclusive of the necessary canals, of some £4,000,000. The site of the dam is three miles below the confluence of the Murrumbidgee and the Goodradigbee Rivers, at a point where the river is confined between two mountains of red granite that rise for 2000 feet above the bed. The dam has a height of 240 feet, with a base 160 feet thick, tapering to 18 feet in width at the top.

The completion of this dam has formed a lake having an area of 12,740 acres, which expanse of water reaches in one direction for a distance of 41 miles, in another direction for 15 miles, and for 25 miles in yet a third. The storage capacity amounts to 33,612,671,000 cubic feet, or 771,640 acre feet—in other words, sufficient water to cover that number of acres to a depth of one foot.

This dam is more than ample for the needs of the Murrumbidgee Irrigation Area, and is, in fact, the fifth largest dam in the world, the largest—the Elephant, at Butte—having a capacity of 2,600,000 acre feet and the well-known one at Assuan, 1,865,000 acre feet.

The water stored in the Burrinjuck Dam is liberated through sluices into the Murrumbidgee River, down which it flows for a distance of 240 miles until the Berembed Weir is reached. At this point the requisite water is diverted into the main

A Scene in the Northern Rivers District of New South Wales. Dairying forms the Staple Industry. but the Land is also very well suited to the Cultivation of Cotton.

irrigation canal that will eventually extend for about 120 miles from Berembed, or for some thirty miles beyond the town of Griffith, which forms the centre of the irrigation area and is already served by the canal.

Fruit farming has formed the staple industry of the Murrumbidgee Irrigation Area, but, as during recent years there has been an over-production of fruit, with the consequent decrease in the prices obtainable, many of the settlers are now devoting a portion of their land to the growing of cotton, for they find that cotton may be advantageously planted between the fruit trees, and especially between the young trees before they come

[*Photo* by [*R. Harding*

YOUNG COTTON, GROWING BETWEEN ORANGE TREES NEAR GRIFFITH, MURRUMBIDGEE IRRIGATION AREA OF NEW SOUTH WALES.

into bearing. Fortunately, also, the picking of the cotton crop does not clash with either the harvesting of the vines or the gathering of the citrus fruits.

The Murrumbidgee Irrigation Area may be divided into two sections—the first comprising the districts of Yanco and Leeton, and the second the localities of Griffith and Yenda. Throughout the great majority of both the foregoing districts the surface soil consists of a rich red sandy loam, exceedingly fertile, but in some places very shallow. In the Yanco-Leeton area the surface soil varies in depth from six inches to two feet; and in the Griffith-Yenda district from three feet to four feet. Underlying this surface soil is a hard stratum of lime, or impervious clay, that the roots of neither fruit trees nor cotton can pierce; and, as this hard-pan is equally resistant to the passage of water, danger of water-logging of the soil exists on very level ground, even though the system of drainage that has been installed is one of the most complete and scientific in existence.

In consequence of the comparative shallowness of the surface soil in the vicinity of Yanco-Leeton, this district would not appear to be so well suited to the cultivation of cotton as the Griffith-Yenda area, where the surface soil is of greater depth. In order to guard against the possible danger of suffocation of the cotton plants' root system through water-logging of the soil, it would seem advisable in both the before-mentioned districts to plant only on ground possessing a gentle slope and thereby provided with natural drainage; the districts in the vicinity of Lake View and Beelbangera, near Griffith, are particularly favoured in this respect, as they are endowed with both depth of soil and natural drainage.

Throughout the Murrumbidgee Irrigation Area waterings may be given every fortnight during the six summer months, as the storage capacity of the Burrinjuck Dam is greater than is to-day required for the area it serves. This fact should permit of the successful production of cotton on land having only a comparatively shallow surface soil, and which might otherwise be unsuited to cotton growing. In Egypt the normal water rotations during the growing season consist of six days with water and eighteen days without.

This irrigation district of New South Wales experiences a somewhat greater range of temperatures than other cotton-growing areas of the State, and during the summer it is occasionally subjected to very hot days, when dry westerly winds,

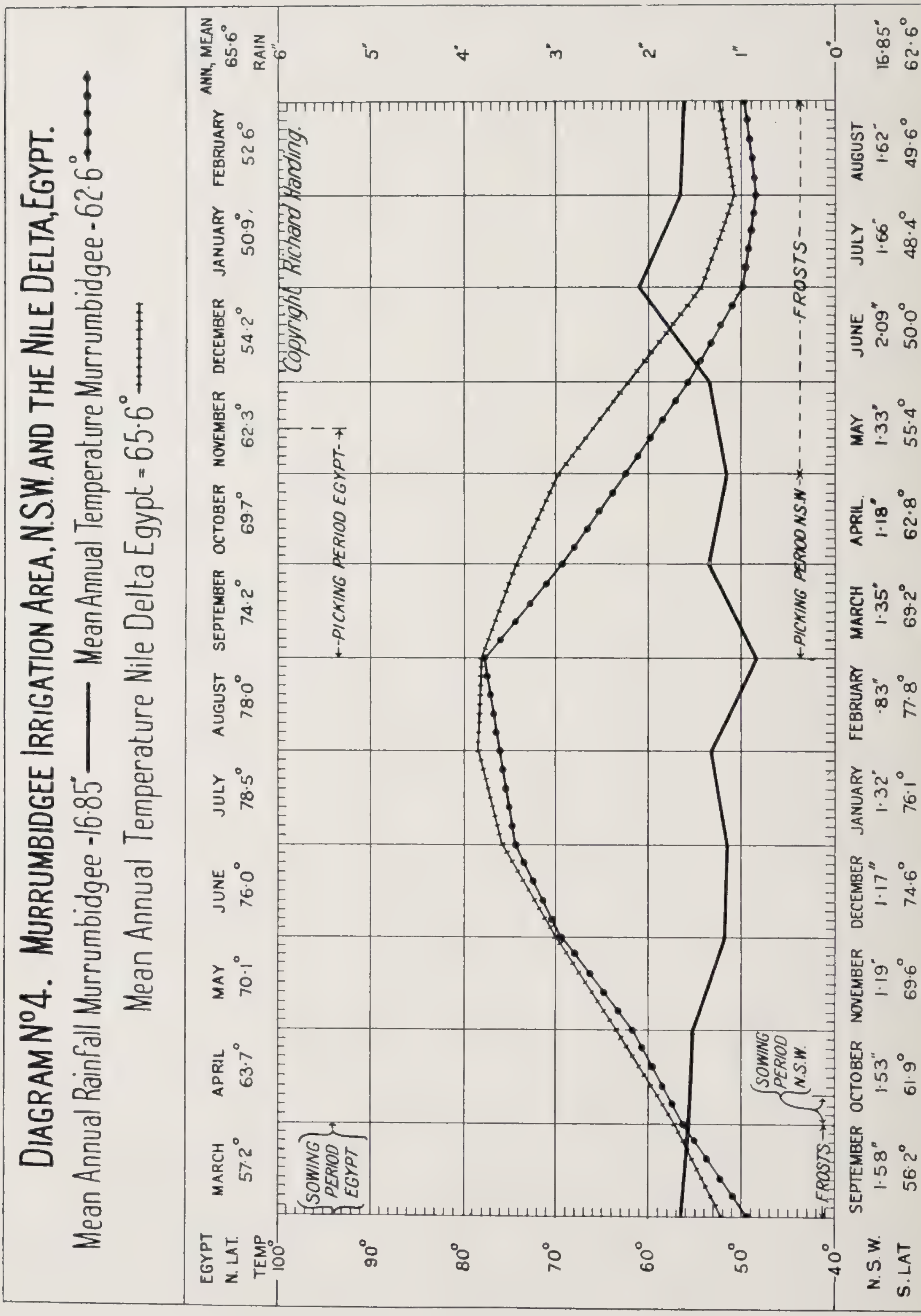


DIAGRAM No 4. MURRUMBIDGEE IRRIGATION AREA, N.S.W. AND THE NILE DELTA, EGYPT.
Mean Annual Rainfall Murrumbidgee - 16·85"
Mean Annual Temperature Murrumbidgee - 62·6°
Mean Annual Temperature Nile Delta Egypt = 65·6°
EGYPT N. LAT.
MARCH 57·2°
APRIL 63·7°
MAY 70·1°
JUNE 76·0°
JULY 78·5°
AUGUST 78·0°
SEPTEMBER 74·2°
OCTOBER 69·7°
NOVEMBER 62·3°
DECEMBER 54·2°
JANUARY 50·9°
FEBRUARY 52·6°
ANN. MEAN 65·6°
TEMP
100°
90°
80°
70°
60°
50°
40°
RAIN
6"
5"
4"
3"
2"
1"
0"
SOWING PERIOD EGYPT
SOWING PERIOD N.S.W.
PICKING PERIOD EGYPT
PICKING PERIOD N.S.W.
FROSTS
Copyright Richard Harding.
N.S.W. S. LAT
SEPTEMBER 1·58" 56·2°
OCTOBER 1·53" 61·9°
NOVEMBER 1·19" 69·6°
DECEMBER 1·17" 74·6°
JANUARY 1·32" 76·1°
FEBRUARY ·83" 77·8°
MARCH 1·35" 69·2°
APRIL 1·18" 62·8°
MAY 1·33" 55·4°
JUNE 2·09" 50·0°
JULY 1·66" 48·4°
AUGUST 1·62" 49·6°
16·85" 62·6°

DIAGRAM No. 4.—MURRUMBIDGEE IRRIGATION AREA, N.S.W. NILE DELTA, EGYPT.

TEMPERATURE, MURRUMBIDGEE IRRIGATION AREA, N.S.W.

Station.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Leeton.—Mean Max.	10	89·7°	89·5°	81·6°	73·7°	64·9°	58·2°	57·1°	60·1°	67·2°	73·9°	81·6°	87·9°	73·8°
,, ,, Min.	10	63·6°	64·8°	57·5°	50·9°	45·4°	41·2°	38·8°	40·5°	45·0°	50·0°	55·8°	61·9°	51·3°
,, Mean	10	76·6°	77·2°	69·5°	62·3°	55·4°	49·7°	47·9°	50·3°	56·1°	62·0°	68·7°	74·9°	62·5°
Griffith.—Mean Max.	3	89·4°	91·5°	83·0°	74·8°	66·1°	59·9°	58·5°	59·3°	67·1°	75·0°	84·8°	86·7°	74·7°
,, ,, Min.	3	61·9°	65·2°	55·1°	51·7°	44·5°	40·9°	39·3°	38·7°	45·6°	48·6°	56·0°	62·1°	50·8°
,, Mean	3	75·6°	78·4°	69·0°	63·3°	55·3°	50·4°	48·9°	49·0°	56·3°	61·8°	70·4°	74·4°	62·8°
Mean Average	6½	76·1°	77·8°	69·2°	62·8°	55·4°	50·0°	48·4°	49·6°	56·2°	61·9°	69·6°	74·6°	62·6°

RAINFALL AND EVAPORATION, MURRUMBIDGEE IRRIGATION AREA, N.S.W.

Station.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Leeton—Rainfall	31	1·32″	0·83″	1·35″	1·18″	1·33″	2·09″	1·66″	1·62″	1·58″	1·53″	1·19″	1·17″	16.85″
Leeton—Evaporation	4	8·79″	7·19″	5·38″	3·21″	2·18″	1·37″	1·27″	1·61″	2·89″	4·27″	6·79″	7·93″	52·88″

TEMPERATURE, NILE DELTA, EGYPT

Station.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Sakha.—Max.	13	64·9°	67·1°	71·8°	80·1°	87·1°	92·1°	93·3°	93·3°	89·2°	84·5°	77·0°	68·0°	80·6°
,, Min.	13	42·4°	42·4°	45·3°	49·6°	54·6°	60·1°	63·5°	64·0°	61·5°	56·8°	51·8°	44·6°	53·0°
,, Mean of Day	13	51·1°	52·3°	56·3°	63·1°	69·2°	75·2°	77·7°	77·3°	74·1°	69·6°	62·2°	54·1°	65·1°
Qorashiya.—Max.	13	66·5°	68·3°	74·1°	81·5°	89·1°	94·4°	96·1°	95·0°	89·9°	85·1°	77·3°	69·0°	82·4°
,, Mean	13	40·4°	41·7°	45·6°	50·3°	55·4°	61·3°	64·7°	65·3°	61·5°	57·9°	51·8°	44·4°	53·4°
,, Mean of Day	13	50·7°	52·8°	58·1°	64·4°	71·1°	76·8°	79·3°	78·8°	74·4°	69·9°	62·4°	54·3°	66·2°
Average of Mean of Days	13	50·9°	52·6°	57·2°	63·7°	70·1°	76·0°	78·5°	78·0°	74·2°	69·7°	62·3°	54·2°	65·6°

with temperatures of over 100°, may be expected to cause a certain amount of ‘ shedding ’ of flowers and squares.

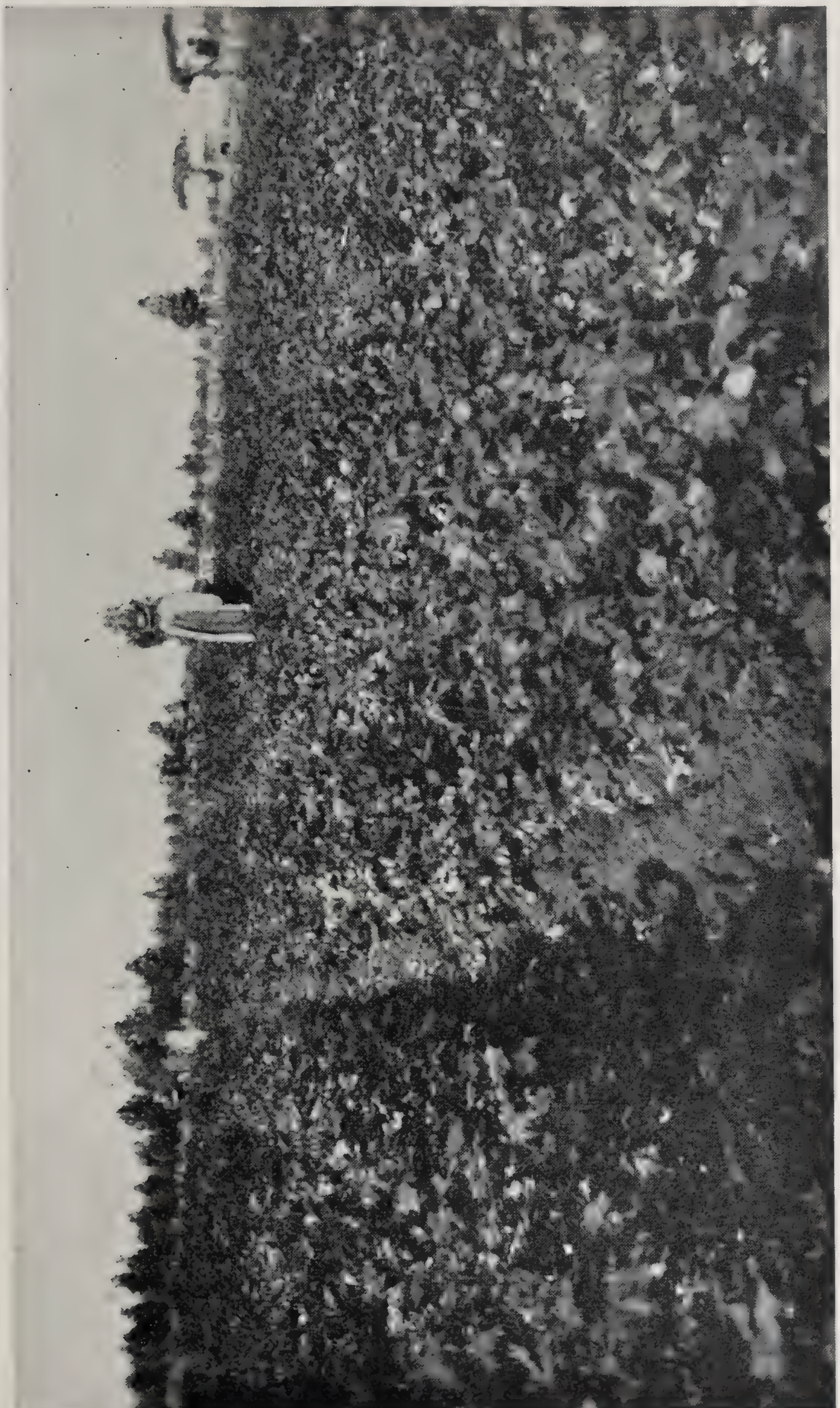
During the winter months frosts are of frequent occurrence and, although they are never very severe, they are usually heavy enough to kill cotton. The frost period may be said to be from May to September, as only during exceptional seasons are frosts experienced during the month of May or after the first week in October.

Diagram No. 4 illustrates the manner in which the temperature rises between the beginning of October and the end of January, together with the rapidity in which it decreases between the beginning of March and the end of June, thereby giving the Murrumbidgee Irrigation Area a comparatively short growing season. If the fullest use is to be made of the climate, it would seem advisable to plant cotton about *October 1 to 7*, as, if the seeds are sown at about that period, then the young plants will appear above the ground by the 7th or 15th of that month, when danger of frosts is over.

The limited experience that has to date been acquired of the growing of cotton under irrigation in Australia has demonstrated that the surest ‘ strike ’ and the best results have been obtained by first irrigating the land and then sowing the seeds in the moist soil after the water has been drained off ; this method is at present employed in the Murrumbidgee Irrigation Area and has so far proved successful, but further experiment in this direction is desirable.

From the end of October until the end of February surface evaporation is very great owing to the strength of the sun, and, if planting is delayed until the month of November, not only will difficulty be experienced in obtaining germination owing to the rapid drying of the surface soil, but the plants will tend towards rank growth and will also fail to give their maximum yield, as much of the top-crop will be prevented from maturing by the cold weather in the autumn. American Upland cotton will probably prove to be more suited to this district, and should give greater yields than Egyptian varieties that require a longer period to reach maturity.

The foregoing statement is substantiated by Diagram No. 4, which illustrates the mean temperature of the Murrumbidgee Irrigation Area, together with those of certain places situated in about the centre of the Nile Delta in Egypt. The Egyptian data have been supplied by courtesy of Mr. R. S. Sennitt, B.Sc., who obtained them from the Ministry of



Upland Cotton Grown on Mr. Dunbar's Block, at Griffith, Murrumbidgee Irrigation Area, Season 1922–23.

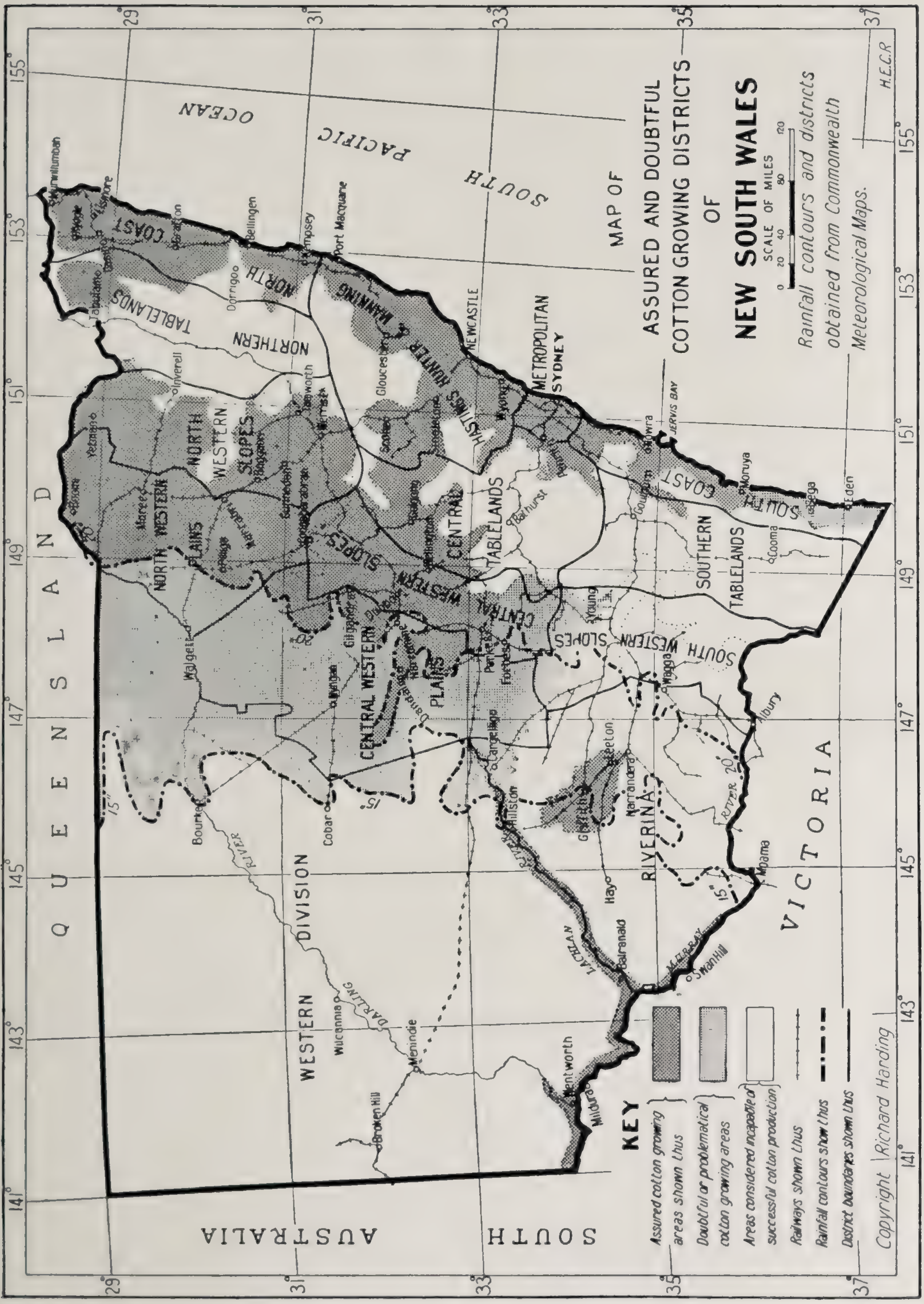
Public Works—Physical Department, Cairo, Egypt. The 'Mean of Day' for each month has been obtained by adding the records taken at 8.0 A.M., 2.0 P.M., 8.0 P.M. and the minimum temperature, and dividing by four. (For full particulars of Egyptian temperature see Appendix No. I.)

In Diagram No. 4 the seasons of the year in the Northern and the Southern hemispheres have been synchronised in a similar manner to that employed in Diagram No. I. The Egyptian figures represent the averages of the mean temperatures of Sakha, latitude 31° 7′ N., longitude 30° 57′ E., and of Qorashiya, latitude 30° 51′ N., longitude 31° 7′ E.; and, although it may not be fair to compare places in about latitude 31° N. with areas in latitude 34° 30′ S., as there is a difference of some 3° 30′ between their respective distances from the Equator, yet the marked difference that exists between the mean Egyptian temperatures and those of the Murrumbidgee Irrigation Area points to the unsuitability of the latter district for the cultivation of ordinary Egyptian varieties of cotton.

The irrigating of the crop in Australia and the number of waterings that are applied are almost as important as the date on which the crop is sown; for, if irrigations are continued until late in the season, many of the bolls will rot upon the plants instead of maturing. In this respect Egyptian irrigation experience should prove of value, and it would seem wise to follow Egyptian methods until such time as fuller experience is obtained of cotton under irrigation in Australia.

Roughly summarised, cotton grown in the Egyptian Delta receives its first watering directly after sowing, during the middle of March. The second watering is applied about the middle of May, some sixty days after the first; and the third watering some thirty days later, or about June 15. From then onwards the crop receives irrigations as often as the water rotations will permit, *i.e.* every eighteenth or twentieth day. The seventh and final irrigation in Egypt is given at the end of August, or some 168 days after the first watering. Picking generally commences at the beginning of September, 180 to 200 days after sowing, and continues for roughly sixty days; thus the cotton season in Egypt occupies approximately 250 days from the sowing of the crop to the termination of picking.

As the Murrumbidgee Irrigation Area does not possess as deep a soil as the Nile Delta, it will probably prove to be


MAP OF
ASSURED AND DOUBTFUL
COTTON GROWING DISTRICTS
OF
NEW SOUTH WALES
SCALE OF MILES
0 20 40 80 120
Rainfall contours and districts
obtained from Commonwealth
Meteorological Maps.
KEY
Assured cotton growing areas shown thus
Doubtful or problematical cotton growing areas
Areas considered incapable of successful cotton production
Railways shown thus
Rainfall contours shown thus
District boundaries shown thus
Copyright Richard Harding
H.E.C.R.
QUEENSLAND
VICTORIA
SOUTH AUSTRALIA
SOUTH PACIFIC OCEAN
NORTH COAST
NORTHERN TABLELANDS
NORTH WESTERN SLOPES
NORTH WESTERN PLAINS
CENTRAL WESTERN SLOPES
CENTRAL WESTERN PLAINS
CENTRAL TABLELANDS
HUNTER MANNING
METROPOLITAN
SYDNEY
SOUTH COAST
SOUTHERN TABLELANDS
SOUTH WESTERN SLOPES
RIVERINA
WESTERN DIVISION

necessary to irrigate more frequently, and the following system of irrigation would seem advisable: First watering and the sowing of the crop, October 1 to 7; second watering, November 15; third watering, December 15, then at fortnightly intervals; the sixth and final watering for American Upland varieties should be applied at the very *end of January* or the *beginning of February*, some 123 days after sowing.

Whether or not the crop will require six waterings, or a greater or lesser number, is a matter for experiment; but it would seem essential that the *final* irrigation be given at about the beginning of February, as this will force the plants to ripen off their crop during March and before the low autumn temperatures prevent the ripening of the bolls and cause boll-rot.

The Cotton-Growing Areas of New South Wales.—The map illustrating the suitable, the unsuitable and the doubtful cotton-growing areas of the State of New South Wales is based on temperature, rainfall and the data given in Tables Nos. 1, 2, 3 and 4; these tables have been compiled from official publications and from information specially procured from the Government Meteorological Bureau of that State.

The districts that possess the necessary rainfall and suitable climate for successful cotton production have already been discussed: they consist of the coastal belt extending from the Queensland border to Moruya Heads in latitude 36° S., those inland districts known as the North-Western Slopes, the Central Western Slopes, the eastern portion of the North-Western Plains and the Murrumbidgee Irrigation Area, together with a strip of irrigable land along the Rivers Murray and Lachlan, which areas are represented by the deeply shaded portions of the map.

Coastal Belt.—Speaking in very broad terms, the Coastal Belt has an average annual rainfall of from 40 to 60 inches with about 340 days free from frosts, and should, therefore, be able successfully to produce certain varieties of Egyptian cottons and the finer long-stapled strains of American Uplands. Details of the rainfall and frost periods of this coastal belt are given in Table No. 1.

Assured Inland Districts.—The inland districts previously referred to have an annual rainfall of from 20 to 30 inches, with a period of some 260 days free from frosts and, although the mean annual rainfall of these districts of New South Wales may be less than that of other cotton-growing countries, sight should not be lost of the fact that the bulk of the precipitation

TABLE No. 1.—FROST PERIOD, ALTITUDE AND RAINFALL OF NEW SOUTH WALES. COASTAL COTTON-GROWING DISTRICTS

Station.	District.	Distance from East Coast in Miles.	Latitude South.	Longitude East.	Altitude in Feet.	Average Number of Days between First and Last Frosts, 1913–1923.	Average Number of Days free from Frosts, 1913–1923.	Average Annual Rainfall.	Number of Years Records.
Casino	North Coast	28	28° 50′	153° 0′	82	38	327	43·52″	48
Lismore	,, ,,	13	28° 50′	153° 21′	52	35	330	51·05″	38
Clarence Heads	,, ,,	0	29° 25′	153° 23′	122	0	365	55·66″	45
Grafton	,, ,,	22	29° 43′	152° 56′	40	16	349	35·24″	27
Port Macquarie	Hastings, Hunter and Manning	0	31° 25′	152° 54′	49	14	351	59·93″	60
Murrurundi	,, ,,	84	31° 46′	150° 49′	1545	122	243	31·21″	50
Taree	,, ,,	8	31° 55′	152° 29′	30	59	306	45·28″	38
Scone	,, ,,	78	32° 4′	150° 53′	680	132	233	24·11″	45
Newcastle	,, ,,	1	32° 55′	151° 50′	34	0	365	46·41″	57
Maitland	,, ,,	18	32° 47′	151° 35′	40	46	319	34·01″	54
Sydney	Metropolitan	5	33° 51′	151° 13′	146	0	365	48·04″	63
Picton	South Coast	22	34° 10′	150° 36′	549	148	217	30·65″	42
Wollongong	,, ,,	0	34° 25′	150° 56′	54	2	363	46·02″	48
Nowra	,, ,,	6	34° 55′	150° 38′	30	8	357	38·75″	38
Moruya	,, ,,	0	35° 53′	150° 6′	50	8	357	34·93″	46

TABLE No. 2.—FROST PERIOD, ALTITUDE AND RAINFALL OF NEW SOUTH WALES. INLAND COTTON-GROWING DISTRICTS.

Station.	District.	Distance from East Coast in Miles.	Latitude South.	Longitude East.	Altitude in Feet.	Average Number of Days between First and Last Frosts, 1913–1923.	Average Number of Days free from Frosts, 1913–1923.	Average Annual Rainfall.	Number of Years Records.
Warialda . .	North-Western Slopes	162	29° 35′	150° 37′	1,106	135	230	28·09″	43
Gunnedah . .	,, ,, ,,	156	31° 1′	150° 15′	874	108	257	24·25″	44
Tamworth . .	,, ,, ,,	122	31° 6′	150° 56′	1,240	134	231	27·39″	41
Quirindi . .	,, ,, ,,	115	31° 32′	150° 38′	1,278	145	220	27·60″	39
Moree . .	North-Western Plains	204	29° 29′	149° 53′	680	86	279	23·63″	42
Narrabri . .	,, ,, ,,	193	30° 20′	149° 46′	697	94	271	26·08″	51
Dubbo . .	Central Western Slopes	177	32° 18′	148° 35′	863	115	250	22·13″	49
Wellington . .	,, ,, ,,	175	32° 35′	148° 58′	995	127	238	23·01″	40
Parkes . .	,, ,, ,,	172	33° 9′	148° 10′	1,035	78	287	20·92″	31
Leeton . .	Murrumbidgee Irrigation Area	220	34° 32′	147° 42′	271	104	261	16·85″	31

TABLE NO. 3.—FROST PERIOD, ALTITUDE AND RAINFALL OF NEW SOUTH WALES. DOUBTFUL OR PROBLEMATICAL COTTON-GROWING DISTRICTS.

Station.	District.	Distance from East Coast in Miles.	Latitude South.	Longitude East.	Altitude in Feet.	Average Number of Days between First and Last Frosts, 1913–1923.	Average Number of Days Free from Frosts, 1913–1923.	Average Annual Rainfall.	Number of Years Records.
Tenterfield . .	Northern Tablelands	80	29° 5′	152° 4′	2,827	167	198	32·30″	51
Glen Innes .	,, ,,	90	29° 43′	151° 44′	3,518	154	211	31·83″	40
Inverell . .	North-Western Slopes	124	29° 48′	151° 10′	1,980	168	197	30·46″	47
Bundarra . .	,, ,,	128	30° 11′	151° 5′	2,000	167	198	30·17″	36
Coonabarabran .	Central Western Slopes	185	31° 16′	149° 18′	1,710	166	199	28·61″	42
Forbes . .	,, ,,	176	33° 27′	148° 5′	789	113	252	19·84″	46
Cassilis (Dalkeith)	Central Tablelands	120	32° 0′	150° 0′	1,500	166	199	23·58″	50
Mudgee . .	,, ,,	121	32° 35′	149° 35′	1,635	171	194	25·75″	47
Cowra . .	,, ,,	119	33° 51′	148° 43′	978	146	219	23·75″	36
Grenfell . .	South-Western Slopes	181	33° 54′	148° 9′	1,238	148	217	24·22″	36

occurs during the summer months, when the plants have most need of moisture. These inland districts, the data for which are contained in Table No. 2, should therefore be able successfully to produce the ordinary American Upland varieties that need a shorter growing period and can be brought to maturity on a lower rainfall than those which are required for either Egyptian or the finer varieties of long-stapled American Uplands.

Doubtful Districts.—The doubtful cotton-growing areas are more difficult to define, for they embrace certain belts of country on the higher slopes of the coastal mountain range that have the requisite rainfall and doubtful temperatures, together with those districts further inland that possess the necessary temperatures but have a barely sufficient rainfall. Only experiment under field conditions can decide this point ; but the manner in which the crop is cultivated, the preparation of the land previous to the planting of the crop and the varieties sown, will prove to be of supreme importance in those areas that have suitable temperatures but a low rainfall. Thus the requisite temperature may be said to be of more importance than the rainfall, always provided that the rainfall, although scanty, occurs at the correct period of the year ; and the success or failure of the crop would thus appear to depend to a great extent on the methods of farming employed by the individual. In this respect the experience that has been gained with the growing of wheat in the comparatively dry areas of New South Wales and other States in Australia may well prove to be equally applicable to the cultivation of cotton. To-day, wheat is being grown successfully in many districts in New South Wales that thirty years ago were considered to be quite unsuited to the cultivation of any crop, and which were regarded by the Department of Agriculture as only adapted to grazing. Thanks to the improved varieties of wheat, bred and introduced by Mr. William Farrer, to modern machinery, and to improved methods of farming and fallowing whereby two years' rainfall can be conserved in the soil and be made to serve for one crop, the wheat belt has gradually crept further and further West into the regions of low rainfall, with the result that one now finds wheat being grown in areas that possess only a 9 to 15 inch rainfall.

If it has been possible to achieve this result with a shallow rooted crop such as wheat, then the same should apply with greater force to cotton that has the advantage of being a deep rooted plant.

TABLE No. 4.—FROST PERIOD, ALTITUDE AND RAINFALL OF NEW SOUTH WALES. UNSUITABLE COTTON-GROWING DISTRICTS.

Station.	District.	Distance from East Coast in Miles.	Latitude South.	Longitude East.	Altitude in Feet.	Average Number of Days between First and Last Frosts, 1913–1923.	Average Number of Days Free from Frosts, 1913–1923.	Average Annual Rainfall.	Number of Years Record.
Armidale	Northern Tableland	81	30° 32′	151° 38′	3,333	175	190	31·77″	56
Molong	Central Tableland	154	33° 7′	148° 52′	1,736	181	184	28·16″	37
Orange	,, ,,	124	33° 18′	149° 9′	2,843	190	175	35·26″	50
Bathurst	,, ,,	96	33° 24′	149° 14′	2,320	174	191	23·93″	63
Goulburn	Southern Tableland	54	34° 45′	149° 45′	2,129	182	183	24·84″	57
Yass	,, ,,	92	34° 52′	148° 56′	1,657	184	181	23·98″	39
Queanbeyan	,, ,,	60	35° 20′	149° 15′	1,899	194	171	22·49″	51
Kiandra	,, ,,	88	35° 52′	148° 32′	4,640	324	41	64·42″	47
Cooma	,, ,,	52	36° 12′	149° 9′	2,637	221	144	19·08″	57
Bombala	,, ,,	29	36° 54′	149° 12′	3,001	228	137	23·22″	37
Moss Vale	South Coast	31	34° 32′	150° 23′	2,205	178	187	38·37″	49
Braidwood	,, ,,	27	35° 28′	149° 49′	3,157	219	146	27·32″	44
Cootamundra	South-Western Slopes	154	34° 39′	148° 1′	1,082	171	194	23·20″	33
Wagga Wagga	,, ,, ,,	158	35° 7′	147° 7′	615	124	241	21·40″	50
Albury	,, ,, ,,	175	36° 6′	147° 0′	531	117	248	27·95″	55
Corowa	Riverina	189	36° 0′	146° 24′	503	96	269	20·30″	32

Although it is admitted that those far inland districts that come under the influence of the summer monsoons, yet only receive an annual rainfall of from 15 to 20 inches, cannot expect to produce as fine or as long stapled a cotton as the coastal districts, they should nevertheless be able to produce a cotton of good, though possibly rather coarse and short staple, provided due attention is given to dry-farming and to the selection of suitable strains.

The doubtful cotton-growing areas are indicated on the map by ruled shading, and data relating thereto are given in Table No. 3.

Unsuitable Areas.—The unsuitable cotton-growing districts of New South Wales may be grouped under three headings, namely: unfavourable temperatures, insufficient rainfall and unseasonable precipitation; all of which may be defined with a fair degree of accuracy and are shown on the map as the white, or unruled and unshaded portions.

The areas of unfavourable temperatures consist of the Northern, the Central and the Southern Tablelands; where the frost-free period varies from about 190 to 130 days or less, according to the altitude and the latitude of the places concerned. Speaking in broad terms, it may safely be said that, with very few exceptions, all localities having an altitude of 2000 feet or over may be considered as unsuited for cotton growing; as even should such districts possess nearly 200 days free from frosts, the low night temperatures during much of that period must result in retarding the development of the plants and consequently cause a reduction in yield.

The regions of insufficient rainfall comprise the western portions of the State, where the annual precipitation amounts to less than 15 inches; as no matter how thorough the methods of cultivation, the hot dry days so often experienced during the summer in these far inland districts, coupled with their low rainfall, will prohibit them from producing cotton of high value.

The southern portion of the State may also be classed as unsuitable as it lies within the winter rain belt, and cotton cannot therefore be successfully produced unless irrigation is available during the summer months when the natural rainfall is deficient. Thus, although many places such as Wagga Wagga, Albury and Corowa possess the requisite temperatures and length of growing season, not only will the lack of rain during the summer prove detrimental to the crop, but the

increase in rainfall during the autumn, which continues throughout the winter, will interfere with the picking, and will in all probability damage any cotton that the plants produce.

Data relating to the unsuitable cotton-growing districts are given in Table No. 4.

Cotton Seed applied for by New South Wales Growers for Planting during the 1923-24 Season.—This is shown in the following table :

New South Wales Districts.	Number of Growers.	Acres.
North Coast	227	689
Hastings, Hunter and Manning	294	805
Metropolitan and South Coast	433	1,194
North-Western Plains and North-Western Slopes .	727	3,978
Central Western Slopes and Central Western Plains	724	4,752
Irrigation areas	106	507
Riverina and South Western Slopes . . .	115	549
Total, New South Wales	2,626	12,474

The above figures include all applications up to, and inclusive of, December 1, 1923 ; and it is not anticipated that any appreciable quantity of sowing seed will be applied for after the above-mentioned date. The acreage per head works out at roughly five acres of cotton per settler. Owing to the very dry condition of the ground as the result of the previous season's drought, and to the very scanty and sub-normal rainfall experienced by Northern New South Wales in October, November and December of 1923, it is estimated that not more than a maximum of 6,000 effective acres under cotton in that State can be counted on for the 1923–24 season.

CHAPTER VI

QUEENSLAND—CLIMATE AND RAINFALL

General remarks—Brisbane, Coastal District—Southern Queensland compared with Georgia, U.S.A.—Charleville, South-West District—Central Queensland—Cloncurry, Carpentaria District—The cotton-growing areas of Queensland—Queensland cotton acreages and yields, 1913–23—Cotton-seed applications for season 1923–24.

General Remarks.—Considerations relating to the growing of cotton in Queensland are somewhat simplified as compared with New South Wales ; for throughout the greater portion of Queensland frosts only occur during the mid-winter month of July, while taking the State as a whole it may be said that the frost-free period varies between 320 and 365 days ; consequently, the rainfall and the seasons of the year during which the precipitation occurs are the points of supreme importance.

The Queensland climate is divided into two distinct seasons, the wet season from November to March and the dry season from April to October. Even in the southern portions of the State, where the rainfall is more evenly distributed throughout the year, the wet and dry seasons are nevertheless very clearly defined ; but as one proceeds northward, the difference between the seasons becomes accentuated, and we thus find that in the northern portions of Queensland the year is divided into six months when practically no rainfall occurs, and six months during which heavy rains are experienced. The difference in the rainfall between the northern and the southern extremes of Queensland is well illustrated in Diagrams No. 10, Northern Queensland, and No. 6, Southern Queensland.

What has been said in the preceding chapter concerning the coastal and the inland districts of New South Wales is equally applicable to the State of Queensland ; as the Queensland coastal districts have the more even temperatures and the greater rainfalls, whilst the inland districts possess the

A Queensland Cotton Field ready for Picking.

smaller and less reliable rainfall and are subjected to greater extremes of temperature. The coastal range that so clearly divides the coastal and the inland districts of New South Wales practically terminates at Toowoomba, a town situated about eighty miles inland from Brisbane in Southern Queensland; for from Toowoomba northward, this coastal range, known as the Main Divide, decreases in altitude and recedes from the coast. In the central and northern portions of Queensland the range, now known as the Great Divide, again comes into prominence and attains an altitude of 5,438 feet near Atherton, at which point the mountains approach to within fifty miles of the sea coast. In the vicinity of Cairns and Innisfail the coastal rains are exceedingly heavy due to the proximity of the mountains, the annual precipitation at Innisfail, taken over a twenty-seven year period, amounting to 151·24 inches.

All Queensland comes under the direct influence of the summer monsoonal rains, but, whereas these rains are very dependable in the coastal districts, they become less reliable as one proceeds inland. Thus, in the far inland districts, although the mean average monthly rainfall taken over a good period of years may appear to present a true estimate of the rainfall conditions for that particular area, too much reliance should not be placed on it, as such averages are often composed of months when the rainfall has been very subnormal, and of months in other years when it has been greatly above the average.

Brisbane: Coastal District, Southern Queensland.—Brisbane, the capital of Queensland, is situated in latitude 27° 45′ S., longitude 153° 0′ E., ten miles up the estuary of the Brisbane River; and, as it lies on the seaward side of the coastal range, it experiences an even temperature and an ample rainfall. Although little cotton is at present grown in the immediate vicinity of the city itself, the Brisbane rainfall and temperature figures are of great interest, as they extend over a long period of years; and if due allowance is made for local conditions, these data are applicable to great areas of excellent cotton-growing lands that lie to the west and to the north of the city. Thus, Diagram No. 5 may be taken as representative of the Southern Queensland Coastal District, which area roughly comprises a belt of country extending for one hundred miles inland from the seashore and stretches in a northerly direction for some three hundred miles, or almost as far as Rockhampton.

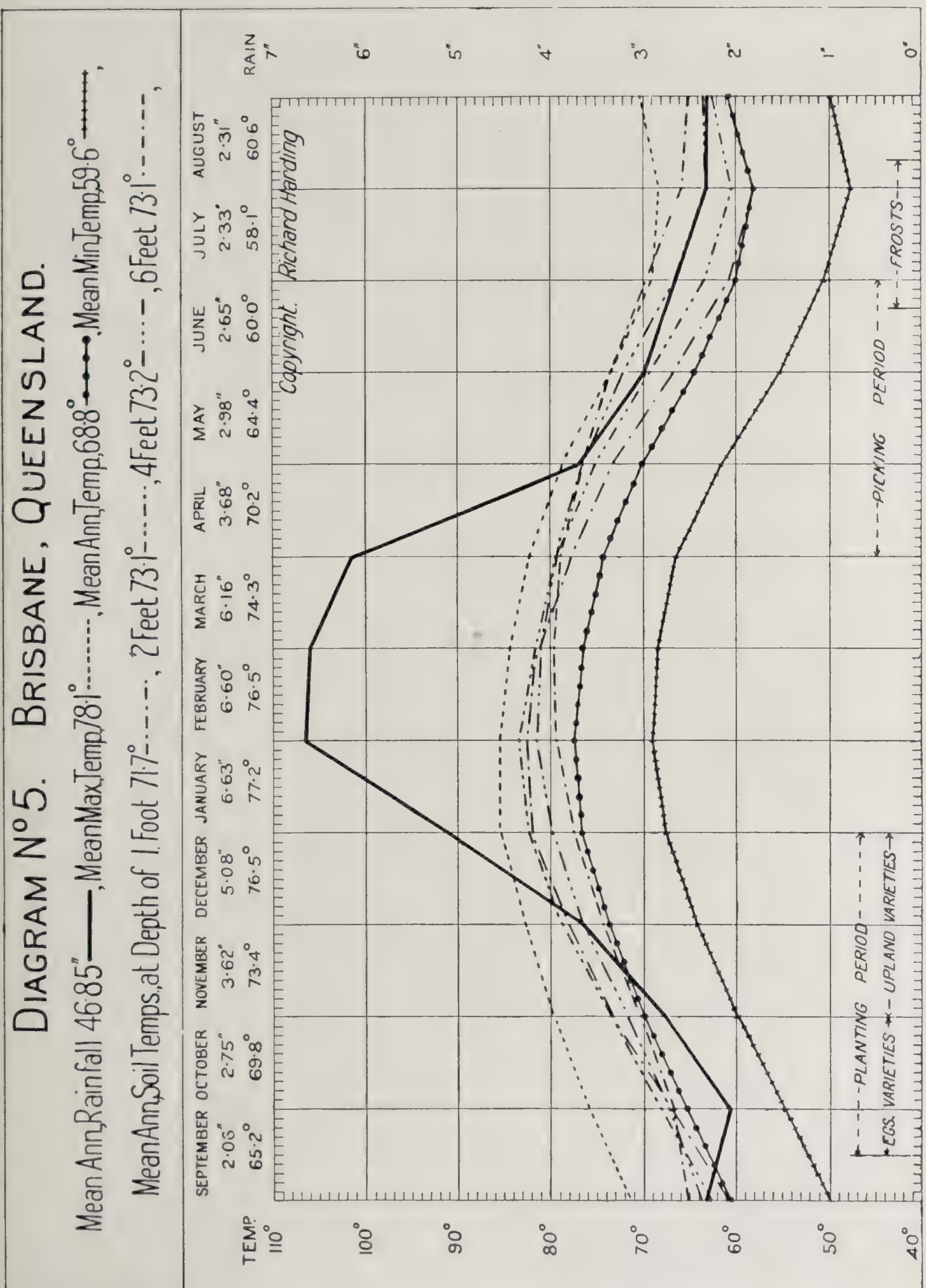


DIAGRAM No 5. BRISBANE, QUEENSLAND.
Mean Ann. Rainfall 46·85", Mean Max. Temp. 78·1°, Mean Ann. Temp. 68·8°, Mean Min. Temp. 59·6°,
Mean Ann. Soil Temps., at Depth of 1 Foot 71·7°, 2 Feet 73·1°, 4 Feet 73·2°, 6 Feet 73·1°,
SEPTEMBER 2·05" 65·2°
OCTOBER 2·75" 69·8°
NOVEMBER 3·62" 73·4°
DECEMBER 5·08" 76·5°
JANUARY 6·63" 77·2°
FEBRUARY 6·60" 76·5°
MARCH 6·16" 74·3°
APRIL 3·68" 70·2°
MAY 2·98" 64·4°
JUNE 2·65" 60·0°
JULY 2·33" 58·1°
AUGUST 2·31" 60·6°
TEMP.
110°
100°
90°
80°
70°
60°
50°
40°
RAIN
7"
6"
5"
4"
3"
2"
1"
0"
Copyright. Richard Harding
PLANTING PERIOD
EGS. VARIETIES
UPLAND VARIETIES
PICKING PERIOD
FROSTS

The average annual rainfall at Brisbane, taken over a period of sixty-two years, amounts to 46·85 in. Over one-third of this average annual precipitation occurs during the three summer months of December, January and February, or over half the annual rainfall, if we include the first autumnal month of March.

The summer climate is humid and warm, whilst the winter climate is cool and comparatively dry, both summer and winter temperatures being free from violent fluctuations. The mean annual temperature is 68·8°, or only 2·4° higher than that of Texas, U.S.A., but despite the slightly higher mean temperature, Brisbane experiences small variations between the monthly means of winter and summer, as the maximum difference between them only amounts to 19·1° F.

Frosts are almost non-existent, as even during the mid-winter month of July there are only three and a half days on which they usually occur ; and only in exceptional years has the thermometer fallen lower than 4° below freezing point.

Throughout the coastal districts of Southern Queensland, represented by Diagram No. 5, there exist almost ideal climatic conditions for successful cotton production, as in addition to the maximum rainfall occurring during the warm summer months, when the plants have most need of moisture, there is sufficient rain during the comparatively dry winter months to soften the surface of the soil so as to permit of ploughing and the preparation of the land for the coming crop.

Owing to the long growing period of approximately 350 days free from frosts, to the good rainfall and to the warm, even temperature of these coastal districts of Southern Queensland, they would appear to be eminently suited to the production of slow-maturing Sea Island and Egyptian varieties of cotton (*vide* Mr. Hill's experiments at Brisbane in 1857 and 1858, Chapter III), or to the cultivation of the finest qualities of long-stapled American Uplands.

A study of Diagram No. 5 indicates that Sea Island or Egyptian varieties of cotton should be planted between September 15 and October 31, say, *October 1* ; whilst if due allowance be made for the shorter period of growth required by American Upland varieties, then these latter should be sown between November 1 and December 31, say, *November 30.* It is evident that these dates will not only ensure the respective crops receiving the greatest assistance from natural rainfall, but will also provide a warm seed bed at planting time, a rising

A Cotton Field of American Upland Variety, Laidley District, Southern Queensland.

DATA RELATING TO BRISBANE, QUEENSLAND

	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Mean monthly rainfall	62	6·63″	6·60″	6·16″	3·68″	2·98″	2·65″	2·33″	2·31″	2·06″	2·75″	3·62″	5·08″	46·85″
Mean maximum shade temperature	26	85·4°	84·5°	82·2°	78·9°	73·5°	69·3°	68·2°	71·2°	75·8°	79·8°	82·7°	85·5°	78·1°
Mean shade temperature	26	77·2°	76·5°	74·3°	70·2°	64·4°	60·0°	58·1°	60·6°	65·2°	69·8°	73·4°	76·5°	68·8°
Mean minimum shade temperature	26	69·0°	68·5°	66·5°	61·5°	55·3°	50·6°	47·9°	49·9°	54·6°	59·8°	64·0°	67·5°	59·6°
Mean maximum wet bulb	12	74·1°	74·1°	72·6°	68·8°	64·2°	59·7°	58·0°	60·3°	63·8°	67·2°	70·7°	74·2°	67·3°
Mean wet bulb	12	70·1°	70·1°	68·6°	64·1°	59·0°	53·9°	52·0°	54·1°	58·0°	62·1°	66·2°	69·9°	62·3°
Mean minimum wet bulb	12	66·0°	66·0°	64·6°	59·3°	53·7°	48·1°	45·9°	47·8°	52·2°	56·9°	61·6°	65·5°	57·3°
Mean humidity	12	65 %	67 %	69 %	67 %	68 %	65 %	64 %	64 %	61 %	63 %	66 %	65 %	65 %
Soil temperature at depth of 1 ft.	25	82·3°	80·8°	77·9°	73·3°	66·9°	60·8°	58·0°	60·8°	66·9°	73·0°	78·4°	81·9°	71·7°
Soil temperature at depth of 2 ft.	25	83·1°	81·8°	79·5°	75·3°	69·6°	63·7°	60·6°	62·4°	67·7°	73·2°	78·6°	82·2°	73·1°
Soil temperature at depth of 4 ft.	25	81·3°	81·0°	79·5°	76·4°	72·1°	66·9°	63·3°	63·5°	67·0°	71·5°	76·3°	79·8°	73·2°
Soil temperature at depth of 6 ft.	25	79·4°	79·7°	79·0°	76·9°	73·5°	69·4°	65·9°	65·0°	66·8°	70·1°	74·1°	77·3°	73·1°
Number of days dew	26	2·6	2·7	4·9	8·3	9·8	7·0	7·5	5·7	5·8	4·1	1·2	1·4	...
Number of days fog	26	0·2	0·4	0·9	1·8	2·7	3·5	2·9	3·4	2·0	1·0	0·3	0·2	...
Number of days frost	26	0	0	0	0	0·4	1·2	3·6	1·5	0·2	0	0	0	...
Number of days thunder	26	2·8	3·0	1·5	0·9	0·3	0·2	0·5	1·4	3·2	4·2	4·7	5·4	...
Mean cloud 0 = clear, 10 = overcast.	26	6·2	6·2	6·0	5·1	4·9	4·3	3·9	4·0	3·8	4·5	5·2	5·6	...

temperature during the period of growth and a dry season for picking.

The soil temperatures of Brisbane were obtained by means of tubes sunk in the ground to the required depths ; three or four inches of water were permitted to remain in the bottom of these tubes, into which the thermometer was lowered and allowed to remain until it registered the temperature of the water. The manner in which the soil temperatures are confined between the mean maximum and the mean air temperatures is rather remarkable. This seems to indicate that the mean minimum air temperatures only represent temperatures occurring during a minor portion of each twenty-four hours, *i.e.* the period immediately preceding the dawn.

As Brisbane is the capital of Queensland, more detailed meteorological information is available for this city than is the case with other and smaller recording stations in that State. Full particulars are given in the table on the opposite page.

Southern Queensland compared with Georgia, U.S.A.—For general simplicity, and in order to present a fair estimate of the climatic conditions ruling over a large tract of country, the Queensland rainfall, illustrated in Diagram No. 6, has been compiled from the averages of the monthly means of several districts, all possessing somewhat similar rainfall and situated in approximately the same latitude—namely, Charleville in the South-Western District, Springsure in the southern portion of the Central District, Roma in the centre of the Maranoa District, Dalby and Goondiwindi in the Darling Downs, and Gayndah in the South Coast District. Places coming under the direct influence of the coastal rains have been purposely excluded, as in this instance it is only desired to show the climatic conditions that prevail throughout the inland districts of the southern portion of Queensland.

The temperature, illustrated in Diagram No. 6, consists of the average of the means of Brisbane and Charleville, and as this average agrees to within 1·5 degrees with the monthly mean temperatures that are experienced at Roma, a town situated almost midway between the two former places, it may also be taken as representative for this portion of the State. Further, as the rainfall records embrace the averages of a period of thirty-eight years, and the temperatures the averages of records covering twenty-three years, this diagram may safely be taken as presenting the normal conditions for that part of Queensland which is approximately confined between

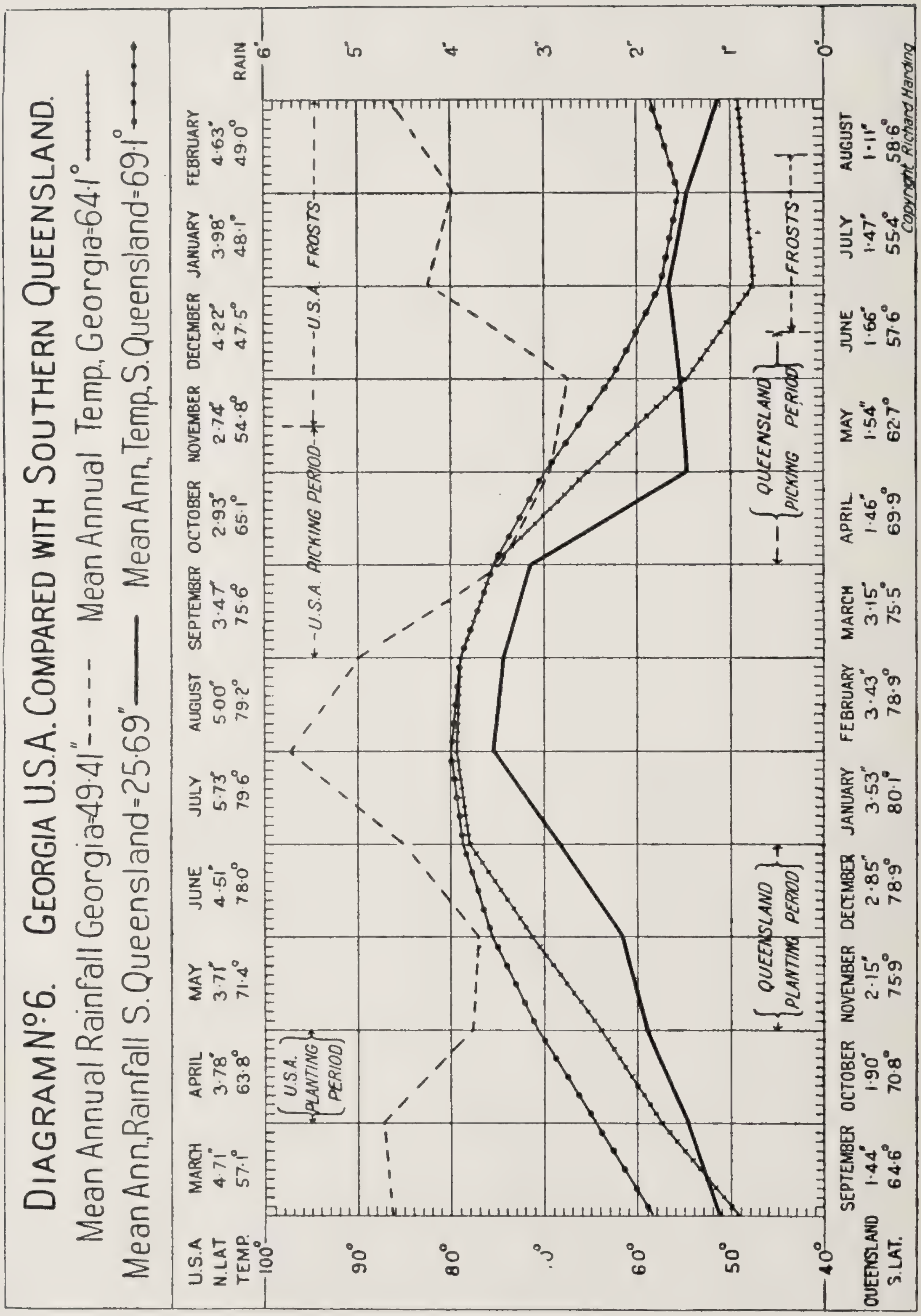


DIAGRAM No. 6. GEORGIA U.S.A. COMPARED WITH SOUTHERN QUEENSLAND.
Mean Annual Rainfall Georgia=49·41" - - - - Mean Annual Temp., Georgia=64·1°
Mean Ann., Rainfall S. Queensland=25·69" —— Mean Ann., Temp., S. Queensland=69·1°
U.S.A. N. LAT. TEMP.
MARCH 4·71" 57·1°
APRIL 3·78" 63·8°
MAY 3·71" 71·4°
JUNE 4·51" 78·0°
JULY 5·73" 79·6°
AUGUST 5·00" 79·2°
SEPTEMBER 3·47" 75·6°
OCTOBER 2·93" 65·1°
NOVEMBER 2·74" 54·8°
DECEMBER 4·22" 47·5°
JANUARY 3·98" 48·1°
FEBRUARY 4·63" 49·0°
RAIN
100° 90° 80° 70° 60° 50° 40°
6" 5" 4" 3" 2" 1" 0"
U.S.A. PLANTING PERIOD
U.S.A. PICKING PERIOD
U.S.A. FROSTS
QUEENSLAND PLANTING PERIOD
QUEENSLAND PICKING PERIOD
FROSTS
QUEENSLAND S. LAT.
SEPTEMBER 1·44" 64·6°
OCTOBER 1·90" 70·8°
NOVEMBER 2·15" 75·9°
DECEMBER 2·85" 78·9°
JANUARY 3·53" 80·1°
FEBRUARY 3·43" 78·9°
MARCH 3·15" 75·5
APRIL 1·46" 69·9°
MAY 1·54" 62·7°
JUNE 1·66" 57·6°
JULY 1·47" 55·4°
AUGUST 1·11" 58·6°
Copyright Richard Harding

DATA RELATING TO DIAGRAM No. 6.—SOUTHERN QUEENSLAND

Rainfall—Southern Queensland

Place.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Charleville . .	23	2·49″	3·14″	3·23″	1·46″	1·41″	1·33″	0·94″	0·58″	0·81″	1·29″	1·34″	2·26	20·28″
Springsure . .	44	3·92″	4·17″	3·19″	1·63″	1·42″	1·80″	1·13″	1·11″	1·21″	1·60″	2·03″	3·00″	26·21″
Roma . . .	39	3·57″	3·16″	3·13″	1·29″	1·62″	1·66″	1·51″	1·00″	1·61″	1·84″	2·12″	2·34″	24·85″
Gayndah . .	42	4·66″	4·29″	3·33″	1·31″	1·65″	1·80″	1·55″	1·31″	1·53″	2·46″	2·84″	3·84″	30·61″
Dalby . . .	43	3·28″	3·02″	2·94″	1·34″	1·39″	1·60″	1·88″	1·31″	1·82″	2·23″	2·60″	3·21″	26·62″
Goondiwindi . .	34	3·23″	2·82″	3·08″	1·70″	1·76″	1·77″	1·81″	1·37″	1·66″	1·95″	1·95″	2·47″	25·57″
Average . .	38	3·53″	3·43″	3·15″	1·46″	1·54″	1·66″	1·47″	1·11″	1·44″	1·90″	2·15″	28·5″	25·69″

Temperature—Southern Queensland

Place.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Brisbane . .	26	72·2°	76·5°	74·3°	70·2°	64·4°	60·0°	58·1°	60·6°	65·2°	69·8°	73·4°	76·5°	68·8°
Charleville . .	19	83·1°	81·4°	76·6°	69·6°	61·0°	55·2°	52·8°	56·6°	64·0°	71·9°	78·4°	81·4°	69·3°
Average . .	23	80·1°	78·9°	75·5°	69·9°	62·7°	57·6°	55·4°	58·6°	64·6°	70·8°	75·9°	78·9°	69·1°

Temperature and Rainfall—Georgia, U.S.A.

Georgia, U.S.A.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Temperature . .	17	48·1°	49·0°	57·1°	63·8°	71·4°	78·0°	79·6°	79·2°	75·6°	65·1°	54·8°	47·5°	64·1°
Rainfall . .	17	3·98″	4·63″	4·71″	3·78″	3·71″	4·51″	5·73″	5·00″	3·47″	2·93″	2·74″	4·22″	49·41″

latitude 25° and 29° S., and which lies to the east of the 146th meridian of east longitude.

As a similarity exists between the climates of Southern Queensland and the south-eastern cotton-growing States of America (especially is this the case during the summer months), and as these two countries are situated in corresponding latitudes on either side of the Equator, one is justified in drawing comparisons between them. This has therefore been done in Diagram No. 6, which has been compiled on the same principle as Diagrams Nos. 1 and 4.

The outstanding features are immediately apparent, namely, the difference between the rainfalls and the temperatures; Georgia, U.S.A., having the greater precipitation, whilst Southern Queensland possesses the more even climate.

Although in excess of the plants' actual requirements, the *type* of rainfall in Georgia, U.S.A., during the growing season is excellent; but it will be noticed that during the picking season, when no rain is needed, Georgia has a much greater precipitation than Southern Queensland. Even though the rainfall in the latter country only amounts to just over half that experienced by Georgia, it is nevertheless sufficient for the requirements of the plants, as the maximum precipitation takes place during the summer.

The evenness of the Australian climate is very marked; for whereas the means of the monthly temperatures in Southern Queensland and in Georgia, U.S.A., are almost identical during the last two summer and the first autumn months—viz. July, August and September in Georgia; and January, February and March in Southern Queensland—Australia has the more temperate climate throughout the rest of the year. The same applies if the monthly mean temperatures of Southern Queensland are compared with the monthly means given at the top of Diagram No. 4 for the Nile Delta in Egypt, as in this case also the freedom of the Queensland climate from extremes is most noticeable. Practically no difference exists between the Egyptian and the Southern Queensland monthly mean temperatures for each of the three summer and the three autumn months, *i.e.* the Egyptian means for each month, June to November inclusive, are almost identical with those of Southern Queensland for the corresponding months of December to May inclusive; but the winter and the spring temperatures of Southern Queensland are appreciably higher than those of either Egypt or Georgia, U.S.A. Thus, as far

as temperature is concerned, Southern Queensland has a longer growing season and a more even climate than either of the

'Cotton Experts,' Darr Creek, Jandowae, North of Dalby, in the Darling Downs District of Southern Queensland.

before-mentioned countries, and she should consequently be able to produce a finer variety of cotton if means of irrigating the crop were available; but the natural rainfall

of 25·69 in. will almost certainly prove inadequate for the successful production of either Egyptian or Sea Island cottons.

The reason for this is to be found in the constitution of the plants themselves. The stems and the leaves of American Upland varieties (*Gossypium hirsutum*) are covered with an innumerable quantity of very fine hairs that hinder the wind from coming into direct contact with the surface of the leaves, and thereby retard the process of evaporation, or sweating, which takes place through the agency of the pores of the leaves—technically known as 'stomata.' Egyptian and Sea Island cottons (*Gossypium peruvianum*) have stems and leaves with a glossy surface, almost devoid of down, or hairs, and consequently, as the breeze is enabled to come into direct contact with the pores of the plant, evaporation occurs at a much greater pace, and such types of cotton have more need of moisture.

There seems to be no doubt, however, concerning the suitability of Southern Queensland for the production of fine, long-stapled American Upland varieties; as in addition to a sufficient and seasonable rainfall there is a growing period of fully six months. Ordinary American types of cotton take approximately five months to reach maturity, and should therefore not be sown previous to November 1, or later than January 1. The optimum planting date for such varieties in Southern Queensland would appear to be *November 30.*

It will be seen that during the month of October there is a suitable temperature and a sufficient rainfall to permit of germination—and therein lies a menace—for if ordinary Upland seed is sown at the beginning of October, then the crop will ripen in February and March, the peak rainfall months. Furthermore, the rainfall in October is mainly composed of thunderstorms having a very local sphere of influence and whose advent cannot always be relied upon; consequently it would seem most advisable to conserve the October rainfall in the soil and to plant during November when the monsoon has commenced in real earnest. As the planting and the picking of the Australian crop are governed by the dates of the normal commencement and cessation of the monsoon, the cotton season in Southern Queensland is seasonally about one month later than in Georgia, U.S.A.

The altitude of these districts of Southern Queensland just discussed varies from about 500 to 1000 ft. Slight frosts are experienced during the winter months, but they are not

[Picking Cotton in Southern Queensland, Season 1922–23.

of sufficient severity to kill full-grown plants. Data relating to Diagram No. 6 are given on page 119.

Charleville, Queensland.—Charleville is an inland town and Government Meteorological Recording Station in the South-West District of Queensland, situated about 300 miles from the Pacific Coast in latitude 26° 27′ S., longitude 146° 9′ E., at an altitude of 975 ft. above the sea level. The mean annual rainfall deduced from records extending over a period of twenty-three years amounts to 20·28 in., whilst the mean annual temperature arrived at from nineteen years records is 69·3 ; *vide* Diagram No. 7.

As Charleville and Brisbane are in approximately the same latitude, the former well inland and the latter almost on the sea-coast, it is of interest to compare diagrams No. 5 and No. 7, as these give a very fair estimate of the climatic extremes to be found in the southern portion of Queensland's cotton belt. It will be seen that the farther one gets from the sea-coast, the less the rainfall and the greater the range of temperatures, and thus Charleville will probably prove to mark about the inland limit of the assured cotton-growing districts of Southern Queensland. Although the rainfall is rather scanty, the bulk of the precipitation occurs in the summer, and land in the vicinity of Charleville should be able to produce certain varieties of cotton with a fair measure of success; but owing to the dry climate and hot winds during the summer, and the rather big range of temperatures, this district will probably only be able to grow a rather coarse and short-stapled cotton.

In Charleville, or other inland districts possessing similar climatic conditions, the planting of cotton is governed by two main factors ; namely, by temperature and by lack of rainfall during certain periods of the year. From May 1 to October 31 the average monthly rainfall barely exceeds one inch ; consequently any attempt made to sow previous to November 1 must almost certainly result in failure.

If cotton is sown at the end of September or the beginning of October, the seeds will lie dormant in the dry soil until germinated as the result of the first good rain or thunderstorm, but the young plants on their appearance above the ground will then run grave risk of withering away and dying, as in normal seasons there is not sufficient moisture in the soil to carry them over the period that may elapse before the next rainstorm occurs or until the monsoon commences. This also

A Typical Cotton Plantation in Central Queensland. This Crop was Grown on Volcanic Soil, Season 1922–23.

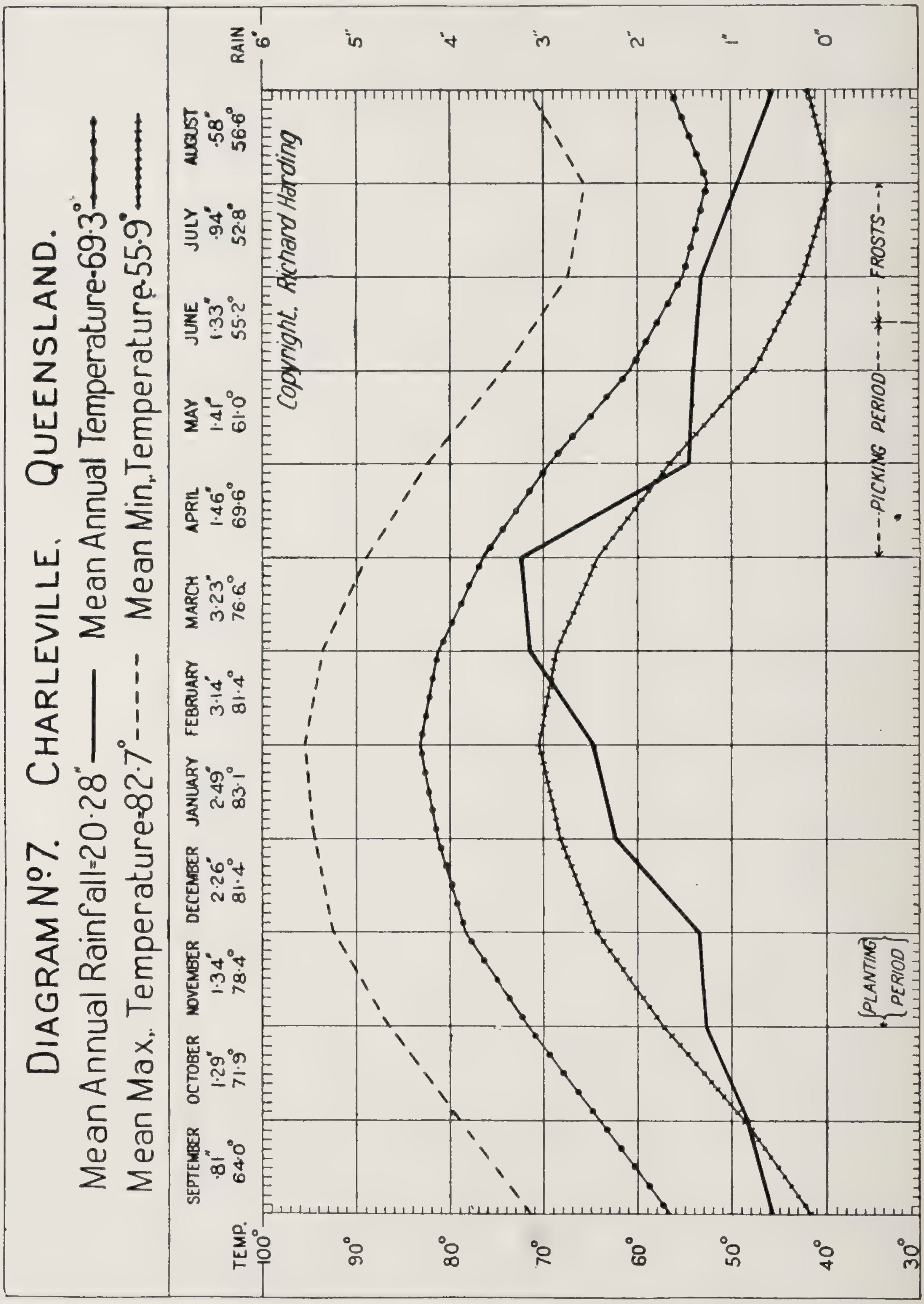


DIAGRAM No. 7. CHARLEVILLE. QUEENSLAND.
Mean Annual Rainfall=20·28″
Mean Annual Temperature=69·3°
Mean Max. Temperature=82·7°
Mean Min. Temperature=55·9°
SEPTEMBER ·81″ 64·0°
OCTOBER 1·29″ 71·9°
NOVEMBER 1·34″ 78·4°
DECEMBER 2·26″ 81·4°
JANUARY 2·49″ 83·1°
FEBRUARY 3·14″ 81·4°
MARCH 3·23″ 76·6°
APRIL 1·46″ 69·6°
MAY 1·41″ 61·0°
JUNE 1·33″ 55·2°
JULY ·94″ 52·8°
AUGUST ·58″ 56·6°
TEMP.
100° 90° 80° 70° 60° 50° 40° 30°
RAIN
6″ 5″ 4″ 3″ 2″ 1″ 0″
Copyright. Richard Harding
PLANTING PERIOD
PICKING PERIOD
FROSTS

DIAGRAM No. 7.—CHARLEVILLE, QUEENSLAND

TEMPERATURE

South-West District of Queensland.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Charleville—														
Mean Maximum .	19	95·6°	93·9°	89·0°	82·7°	74·2°	67·5°	65·9°	71·4°	79·0°	86·3°	92·3°	94·6°	82·7°
Mean Minimum .	19	70·6°	68·8°	64·1°	56·5°	47·8°	42·8°	39·7°	41·9°	48·9°	57·5°	64·4°	68·3°	55·9°
Average Mean Temperature	19	83·1°	81·4°	76·6°	69·6°	61·0°	55·2°	52·8°	56·6°	64·0°	71·9°	78·4°	81·4°	69·3°

RAINFALL

Charleville, Queensland.	Number of Years Records.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Average Rainfall .	25	2·49″	3·14″	3·23″	1·46″	1·41″	1·33″	0·94″	0·58″	0·81″	1·29″	1·34″	2·26″	20·28″

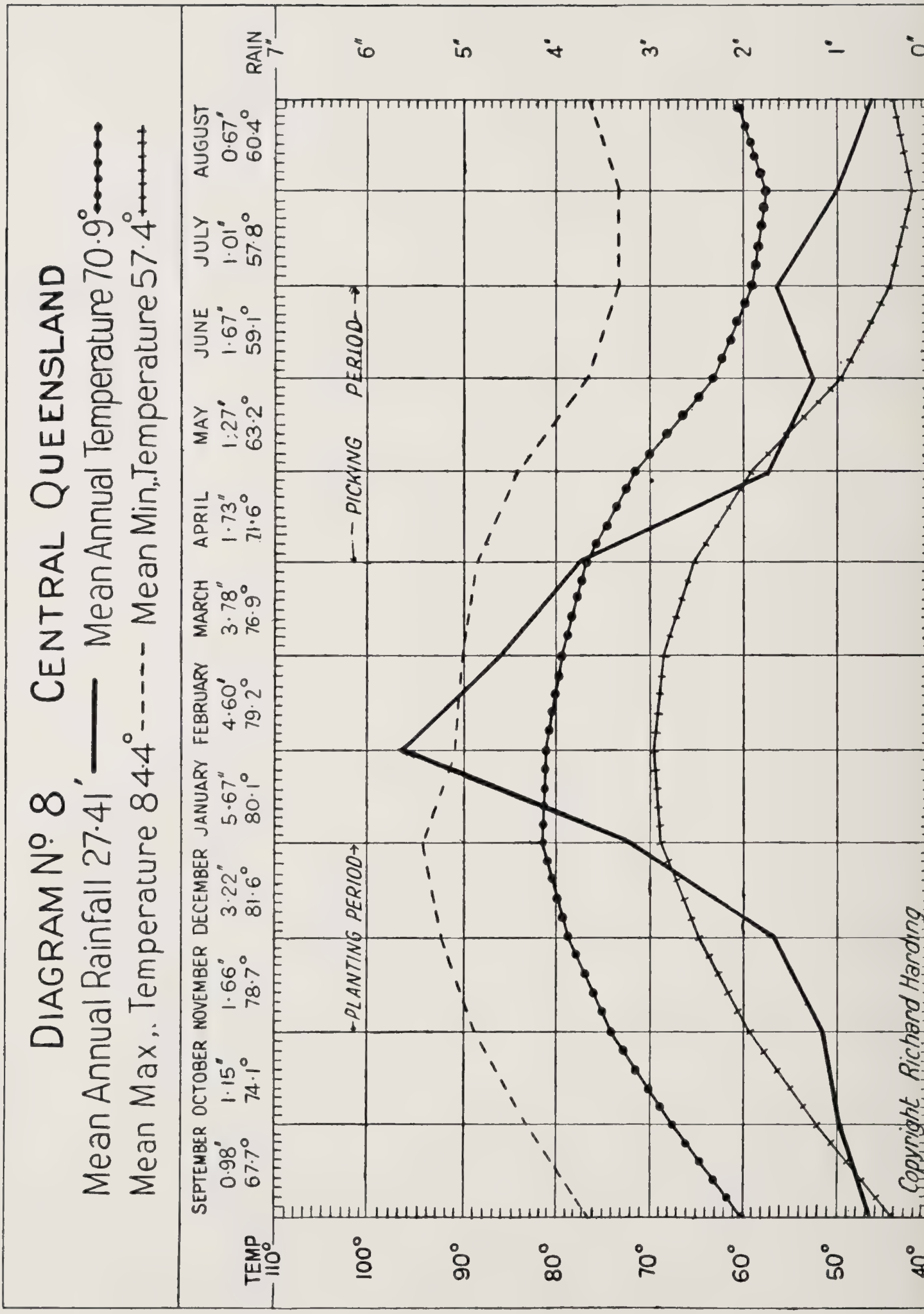


DIAGRAM No. 8 CENTRAL QUEENSLAND
Mean Annual Rainfall 27·41″ —— Mean Annual Temperature 70·9°
Mean Max. Temperature 84·4° - - - - - Mean Min. Temperature 57·4°
SEPTEMBER 0·98″ 67·7°
OCTOBER 1·15″ 74·1°
NOVEMBER 1·66″ 78·7°
DECEMBER 3·22″ 81·6°
JANUARY 5·67″ 80·1°
FEBRUARY 4·60″ 79·2°
MARCH 3·78″ 76·9°
APRIL 1·73″ 71·6°
MAY 1·27″ 63·2°
JUNE 1·67″ 59·1°
JULY 1·01″ 57·8°
AUGUST 0·67″ 60·4°
TEMP
110°
100°
90°
80°
70°
60°
50°
40°
RAIN
7″
6″
5″
4″
3″
2″
1″
0″
PLANTING PERIOD
PICKING PERIOD
Copyright Richard Harding

DATA RELATING TO DIAGRAM No. 8.—CENTRAL QUEENSLAND

Altitude and Rainfall

Place.	Altitude in Feet.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Pentland	1318	23	6·84″	4·10″	4·02″	1·64″	0·69″	1·46″	0·60″	0·41″	0·85″	0·91″	1·24″	3·32″	26·08″
Charters Towers	1019	31	5·72″	4·27″	3·79″	1·73″	0·83″	1·50″	0·58″	0·41″	0·90″	0·76″	1·66″	3·37″	25·52″
Nebo	24	40	6·67″	5·11″	5·00″	2·08″	1·43″	1·77″	1·32″	0·73″	1·20″	0·88″	2·05″	3·72″	31·96″
Elgin Downs	...	21	5·39″	3·99″	2·87″	1·25″	1·11″	1·56″	0·73″	0·86″	0·65″	0·86″	1·16″	2·40″	22·83″
Clermont	870	42	5·05″	4·58″	3·57″	1·78″	1·51″	1·72″	1·08″	0·69″	1·03″	1·35″	1·91″	3·30″	27·57″
Barcaldine	869	26	3·49″	2·97″	2·92″	1·47″	1·57″	1·21″	1·00″	0·47″	0·70″	1·21″	1·26″	2·09″	20·36″
Emerald	588	29	4·31″	3·69″	2·89″	1·56″	1·25″	1·74″	1·09″	0·96″	1·07″	1·52″	1·70″	3·15″	24·93″
Rockhampton	37	42	7·89″	8·13″	5·20″	2·34″	1·79″	2·39″	1·70″	0·84″	1·40″	1·73″	2·32″	4·36″	40·09″
Average	...	32	5·67″	4·60″	3·78″	1·73″	1·27″	1·67″	1·01″	0·67″	0·98″	1·15″	1·66″	3·22″	27·41″

Temperature and Humidity

Clermont.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mean Max. Temperature	11	90·7°	90·0°	88·6°	84·2°	76·8°	73·4°	73·5°	76·6°	83·3°	88·9°	92·6°	94·3°	84·4°
,, Min. Temperature	11	69·5°	68·5°	65·2°	59·1°	49·7°	44·7°	42·1°	44·3°	52·1°	59·3°	64·8°	68·9°	57·4°
Mean Temperature	11	80·1°	79·2°	76·9°	71·6°	63·2°	59·1°	57·8°	60·4°	67·7°	74·1°	78·7°	81·6°	70·9°
Rel. Humidity %	10	66	68	64	63	67	68	66	61	60	55	56	55	62%

holds good in relation to early planting *after* a good fall of rain, for it must be remembered that the subsoil is dry, even though the surface soil may be moist, and the problem is not so much one of securing a good strike, but of keeping the young plants alive and healthy until the advent of the summer rains.

Diagram No. 7 further shows that if Upland varieties of cotton are planted previous to November 1 the crop will then mature during the peak rainfall months of February and March. On the other hand, if planting is delayed until after December, then the crop may suffer from lack of moisture in the final stages of its development, and there also arises the danger of the tail end of the crop failing to mature properly, owing to the low autumn temperatures and to the damage by frost during the end of June and during the month of July.

Charleville district appears to be suitable only for the production of quick maturing and hardy varieties of American Uplands, which Diagram No. 7 indicates should be planted about *November 15* if the maximum result is to be obtained from the crop.

Full details of rainfall and temperatures will be found in the table on page 127.

Central Queensland.—Diagram No. 8 illustrates the normal climatic conditions of the large tract of country embraced by the Central and the Central Coast districts of Queensland. These areas are approximately confined between latitude 20° and 25° S., and between longitude 145° E. and the Pacific Coast. In order to make this diagram as representative as possible, the rainfall records have been taken of eight Meteorological Recording Stations situated at widely divergent points throughout these two districts ; and although in some cases as great a distance as 250 miles separates one station from another, *i.e.* Charters Towers and Emerald, there are no very marked differences in their average monthly or annual precipitations. The two exceptions are, Rockhampton, close to the sea, and Barcaldine, far inland, both places being situated approximately on the Tropic of Capricorn, but, naturally, owing to their respective distances from the coast they show a big difference in rainfall.

As Clermont forms the approximate centre of the Central and Central Coast districts, the Clermont temperatures have been used and may be taken as representative for the two districts now under consideration. The temperatures given in Diagram No. 8 are the average of eleven years' records, and

Delivering W. Smallwood's Seed Cotton at Mareeba Railway Station, July 1923, for Railing to Rockhampton Ginnery.

the rainfall is the average of records extending over a period of thirty-two years.

The outstanding features of this diagram will be found in the gradual accentuation of the dry and the wet seasons, as shown by the manner in which January and February leap into prominence as the peak rainfall months ; and by the way in which these heavy mid-summer rains influence the temperature and prevent the occurrence of extremes. Both the foregoing points are still more prominently emphasised as one proceeds north, and are strikingly illustrated in Diagrams Nos. 10 and 11.

What has been said previously with regard to Southern Queensland (Diagram No. 6) is in general applicable to Central Queensland ; the optimum planting date in either instance being the same, namely, *November 30.*

During the last two seasons, *i.e.* 1921–22 and 1922–23, a great number of small individual areas of cotton have been grown at widely separated points throughout the southern half of Central Queensland, and almost universally throughout Southern Queensland. The experience gained during the American Civil War and in the last two seasons has proved beyond all shadow of doubt that the vast areas of Queensland can produce Upland cotton of the finest quality ; for in the case of American varieties, not only have the cottons when imported given greater yields, but the fibre has proved superior to that produced from similar seed in America—its country of origin.

At the present day the bulk of the cotton cultivation in Queensland is confined to the South Coast, the Darling Downs and the Maranoa districts ; largely because these are the areas most thickly populated and possessing good and reliable rainfall. As the country is sparsely populated to the northward of Rockhampton, this city may be said at present to mark the northern limit of practical cotton growing, but it does not necessarily follow that because cotton is not extensively cultivated in the northern portion of the State the country is unsuited to its production. Experimental patches have been very successfully grown at many places north of Rockhampton and have produced cotton of excellent quality ; but as, so far, no appreciable quantity has been cultivated, one is not justified in making any definite statement concerning these far nothern areas. They must first be thoroughly tested under true field conditions.

Rainfall and temperature figures relating to Central Queensland will be found in the table on p. 129.

Cloncurry, Queensland.—Cloncurry is a Government Meteorological Recording Station situated in the south-western part of the Carpentaria District of Northern Queensland, some 200 miles south of the Gulf of Carpentaria and about 300 miles distant from the Pacific Coast, in latitude 20° 42′ S., longitude 140° 30′ E., at an altitude of 696 feet above mean sea level.

If due allowance be made for the difference in latitude between Cloncurry and Charleville, it will be seen that these two places experience very similar climatic conditions, but that in the case of Cloncurry the rainfall during the summer months and the demarcation between the dry and the wet seasons are more pronounced ; it seems probable that Cloncurry will mark the approximate inland limit of the assured cotton-growing areas of Northern Queensland. There is no record to date of cotton having been grown in this district, but the plotted temperatures and the average rainfall illustrated in Diagram No. 9, page 134, would seem to justify the assumption that country in the vicinity of Cloncurry should be able successfully to produce specific varieties of cotton.

What has been said in relation to Charleville (Diagram No. 7) also applies in a general sense to Cloncurry ; in this district only the cultivation of hardy and quick maturing varieties should be attempted, as the growing season is limited by the intensity and the period of the rainfall, which must render it impossible in normal seasons to obtain successful germination previous to the month of December. *December 15* is indicated as the optimum planting date.

It seems probable, owing to the rapid diminution in the rainfall from March onwards, that cotton sown in this district may ripen more rapidly than in districts with heavier autumn rains, and that the bursting of the majority of the bolls will be almost simultaneous. This should result in a big flush of cotton and enable the greater part of the crop to be gathered in one picking. It will be interesting to see if this is borne out by practical experience in the future.

Climatic data relating to Cloncurry are given in the table on page 135.

The Cotton-Growing Areas of Queensland.—The assured cotton-growing areas of Queensland embrace a belt of country that extends inland from the coasts of the Pacific

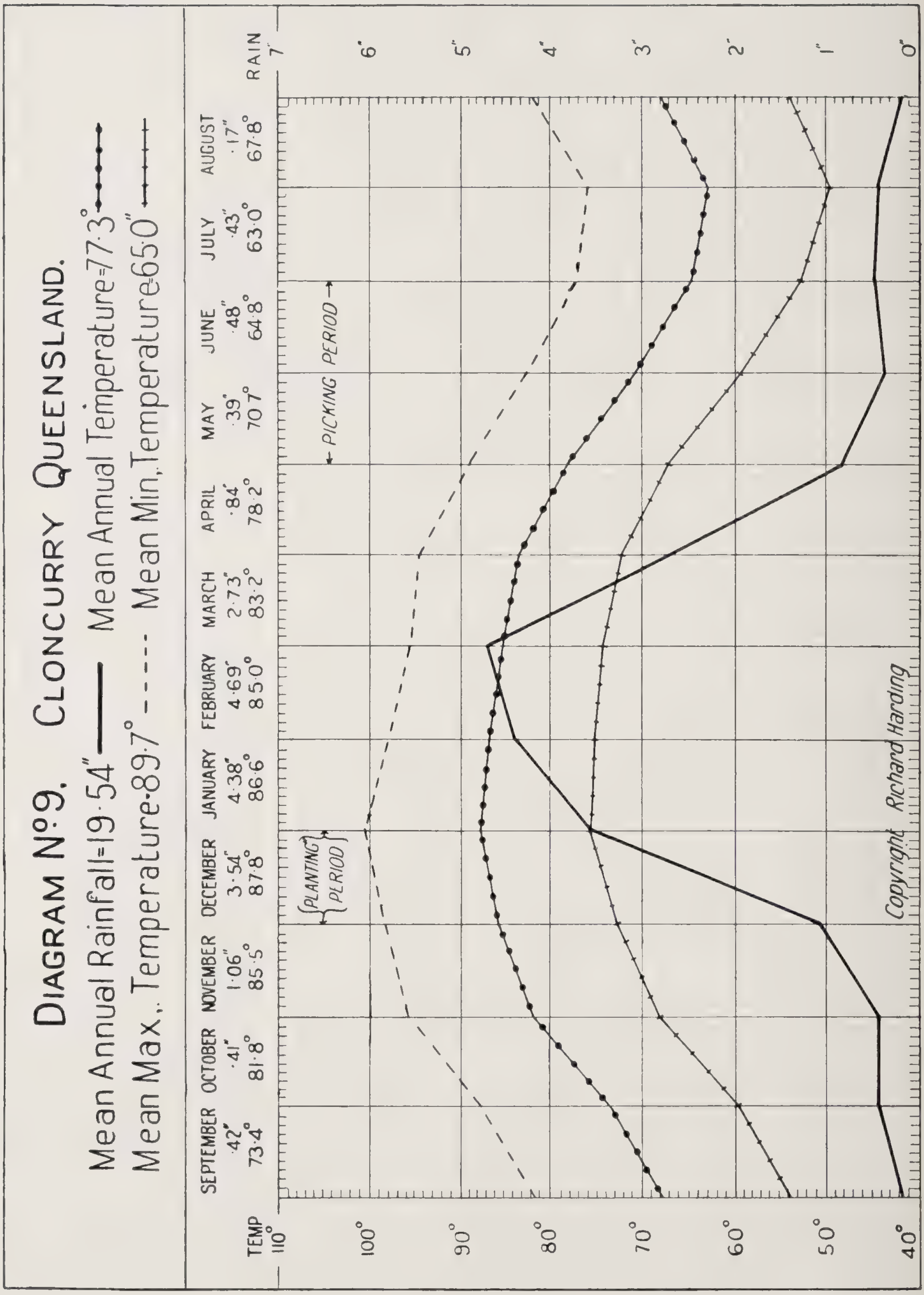


DIAGRAM No. 9. CLONCURRY QUEENSLAND.
Mean Annual Rainfall=19·54″ —— Mean Annual Temperature=77·3°
Mean Max. Temperature=89·7° - - - - Mean Min. Temperature=65·0″
SEPTEMBER ·42″ 73·4°
OCTOBER ·41″ 81·8°
NOVEMBER 1·06″ 85·5°
DECEMBER 3·54″ 87·8°
JANUARY 4·38″ 86·6°
FEBRUARY 4·69″ 85·0°
MARCH 2·73″ 83·2°
APRIL ·84″ 78·2°
MAY ·39″ 70·7°
JUNE ·48″ 64·8°
JULY ·43″ 63·0°
AUGUST ·17″ 67·8°
RAIN 7″ 6″ 5″ 4″ 3″ 2″ 1″ 0″
TEMP 110° 100° 90° 80° 70° 60° 50° 40°
PLANTING PERIOD
← PICKING PERIOD →
Copyright Richard Harding

DATA RELATING TO DIAGRAM No. 9.—CLONCURRY, QUEENSLAND

Temperatures

Cloncurry.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Mean Maximum . .	23	98·0°	95·7°	94·4°	89·3°	82·3°	77·0°	76·1°	81·8°	87·5°	95·5°	98·3°	100·3°	89·7°
Mean Minimum . .	23	75·2°	74·3°	72·1°	67·0°	59·1°	52·7°	49·9°	53·9°	59·4°	68·0°	72·7°	75·4°	65·0°
Mean . . .	23	86·6°	85·0°	83·2°	78·2°	70·7°	64·8°	63·0°	67·8°	73·4°	81·8°	85·5°	87·8°	77·3°

Rainfall

Cloncurry.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual.
Average	29	4·38″	4·69″	2·73″	0·84″	0·39″	0·48″	0·43″	0·17″	0·42″	0·41″	1·06″	3·54″	19·54″


MAP OF
ASSURED AND DOUBTFUL
COTTON GROWING DISTRICTS
OF
QUEENSLAND
SCALE OF MILES
0 100 200 300
Rainfall contours and districts obtained from Commonwealth Meteorological Maps.
Assured cotton growing areas shown thus
Doubtful or problematical cotton growing areas
Areas considered incapable of successful cotton growing
Railways shown thus
Rainfall contours thus
District boundaries thus
Ginning Factories thus
GULF OF CARPENTARIA
PACIFIC OCEAN
PENINSULA
NORTH COAST
CARPENTARIA
CENTRAL COAST
CENTRAL
WESTERN
SOUTH WEST
MARANOA
DARLING DOWNS
SOUTH COAST
NORTHERN TERRITORY
SOUTH AUSTRALIA
NEW SOUTH WALES
Tropic of Capricorn
Thursday Id
Cape York
Mein
Cooktown
Palmerville
Thornsborough
Cairns
Atherton
Normanton
Burketown
Georgetown
Donor's Hill
Townsville
Charters Towers
Camooweal
West Leichhardt
Cloncurry
Hughenden
Pentland
Proserpine
Mackay
Hebo
Tangorin
Ayrshire Downs
Winton
Muttaburra
Elgin Downs
Clermont
Longreach
Barcaldine
Emerald
Rockhampton
Springsure
Gladstone
Wowan
Bundaberg
Jundah
Windorah
Taroom
Gayndah
Maryborough
Roma
Charleville
Gympie
Goondiwindi
Dalby
Wyandra
BRISBANE
Cunnamulla
Bollon
Dirranbandi
Texas
20"
15"
Copyright Richard Harding
H.E.C.R.

QUEENSLAND COTTON ACREAGE AND YIELDS.

Season.	Acreage.	Total Yield in lb. of Seed Cotton.	Yield per Acre in lb. of Seed Cotton.	Yield per Acre in lb. of Lint.	Nett Returns paid to Farmers in Price per lb. of Seed Cotton.	Total Value of Crop.
						£
1913–14	134	20,336	151	50	1·13 pence	209
1914–15	72	12,238	170	57	2·54 ,,	128
1915–16	75	24,264	323	108	2·54 ,,	253
1916–17	133	118,229	889	296	3·58 ,,	1,764
1917–18	203	166,458	820	273	4·35 ,,	3,017
1918–19	73	37,238	510	170	5·5 ,,	853
1919–20	166	57,065	344	115	5·5 ,,	1,308
1920–21	1,967	940,125	478	159	5·5 ,,	21,544
1921–22	6,000	3,887,280	648	216	5·5 ,,	89,083
1922–23 [1]	40,000	11,770,618	269	90	5·5 ,,	269,743
1923–24	100,000	(?)	(?)	(?)	(?)	(?)

[1] Driest season experienced during the last thirty years.

Ocean and the Gulf of Carpentaria for an approximate distance of 250 miles, the inland limit being formed by the 20 in. contour of rainfall. With the exception of a small area of high land near the coast on the southern border of the State, where the coastal range of New South Wales penetrates into Queensland as far as Toowoomba, all the belt of country previously mentioned (shown in map, p. 136, as the deeply shaded portion) should be able successfully to produce cotton in normal seasons, as it possesses both the requisite summer rainfall and temperatures.

The doubtful cotton-growing areas are represented by the lightly shaded districts, and consist of that belt of land that is confined between the 15 in. and the 20 in. contours of rainfall. Hardy varieties might be grown in normal seasons in these areas, if thorough methods of cultivation are employed ; but the great drawback is the unreliability of the rainfall.

COTTON SEED APPLIED FOR BY QUEENSLAND GROWERS FOR PLANTING DURING THE 1923–24 SEASON

Queensland Districts.	Ginnery.	Ginnery Acreage total.	Acreage applied for.	Number of Applicants.
Maranoa . . .			14,432¼	1,092
Toowoomba/Dalby .			1,214¾	166
Darling Downs . .			3,427¾	310
	Dalby . .	19,074¾		
Lockyer . . .			8,684¾	1,237
Ipswich/Boonah . .			2,920¾	537
Brisbane/Valley . .			2,063¾	365
Brisbane/Ipswich .			312¼	59
South Coast . .			813	180
Brisbane/Gympie .			901¼	200
Gympie/Maryborough .			421¼	84
North Queensland .			1,167¼	73
	Whinstanes	17,284¼		
Rockhampton . .			11,826¾	847
Central Line . .			3,460¾	226
Rockhampton/Mackay			4,029¾	276
	Rockhampton	19,317¼		
Gladstone . . .			9,082¾	902
Durango District .			1,273	108
	Gladstone .	10,355¾		
Gayndah/Mundubbera			10,263¾	947
	Gayndah .	10,263¾		
Kingaroy/Nanango .			14,659¼	965
	Wondai .	14,659¼		
Dawson Valley . .			14,750½	475
	Wowan .	14,750½		
		105,694¼	105,694¼	9,113

Coolabuma, in the Kingaroy District of Southern Queensland.

Queensland Cotton Acreage and Yields.—The figures given on page 137 were obtained from statistics published by the Queensland Department of Agriculture and Stock for the years 1913–14 to 1920–21 inclusive. Figures for the years 1921–22 to 1923–24 inclusive were obtained from the British Australian Cotton Association, Limited, who ginned the crop and distributed the necessary sowing seed to growers during this latter period for, and on behalf of, the Queensland Government, who up till 1921 had done this work themselves. The yield of lint per acre has been estimated on the basis of 3 lb. of seed cotton being equal to 1 lb. of lint.

The figures on page 138 include all applications for sowing seed received up to, and inclusive of, December 1, 1923; after which date it was not anticipated that any further appreciable quantity would be distributed. The acreage is based on a sowing of 15 lbs. of cotton seed to the acre.

During the 1922–23 season, the Government supplied intending growers with seed free of charge, and consequently growers applied for more seed than they intended to plant. Much of this 'free' seed was held over and sown during 1923–24, and an allowance of approximately 10 per cent. should be added to the acreage given above, making the total Queensland applications equal to about 115,000 acres.

The Queensland rains in the later half of October, throughout November and during the commencement of December, 1923, were exceptionally good and in many districts exceeded the average; in consequence the effective cotton plantings are estimated at approximately 100,000 acres for that State.

CHAPTER VII

CLIMATE AND RAINFALL

PART I.—NORTHERN QUEENSLAND AND THE NORTHERN TERRITORY. General remarks—Northern Queensland—The Northern Territory—Evans Report —Summary.

PART II.—WESTERN AUSTRALIA. The south-west—The central area—The Kimberley district—Kimberley district soils, Pindan soils, black soils—Summary—Rainfall at Broome.

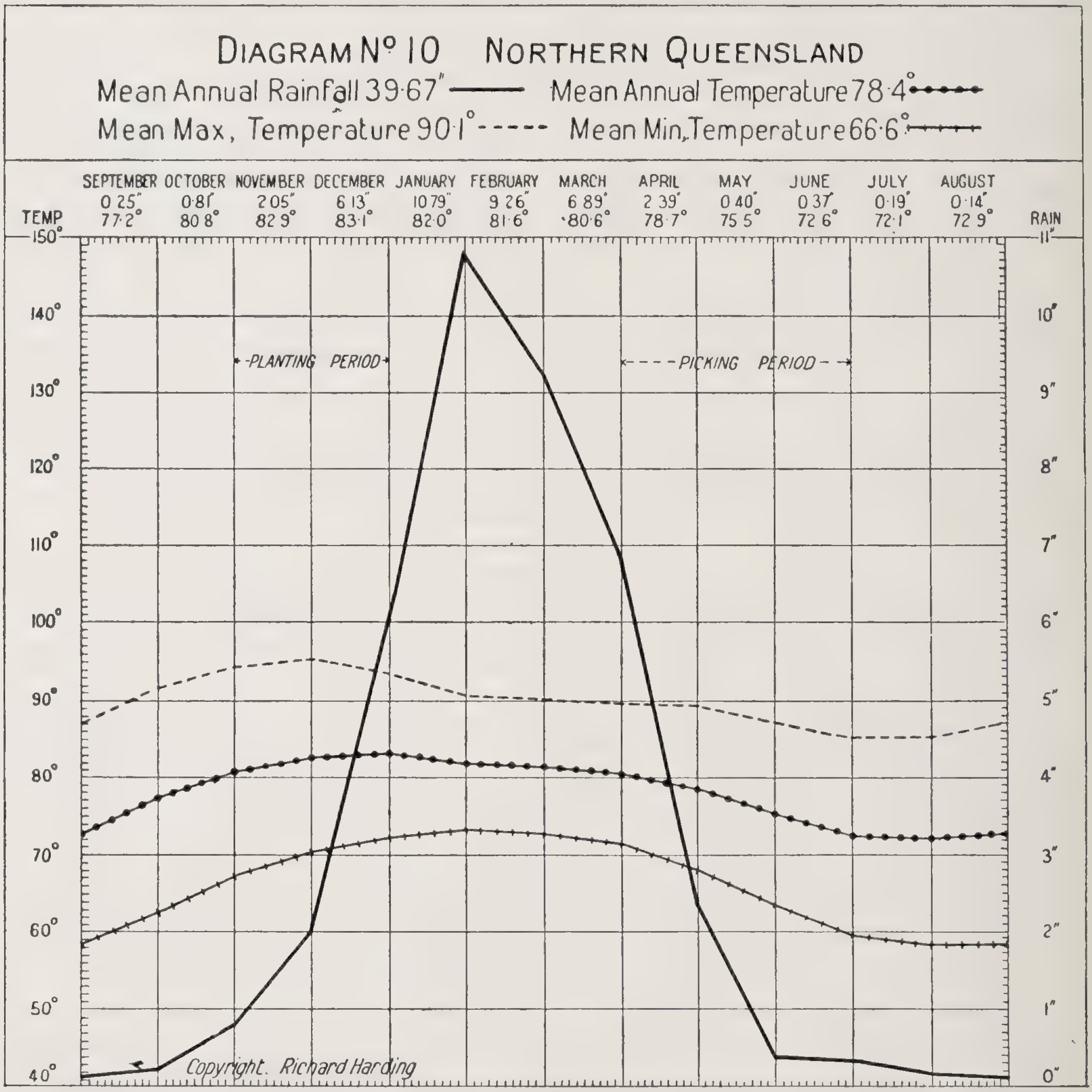
PART III.—IRRIGATION AREAS. The Darling River—The Lachlan River—Murrumbidgee River—River Murray—Berri variety test, River Murray—Estimated cost of production under irrigation—Summary.

PART I—NORTHERN QUEENSLAND AND THE NORTHERN TERRITORY

THE least known and most sparsely populated areas of Australia (except the dry and almost uninhabited central portions of the continent) are Northern Queensland, the Northern Territory and the north-western part of Western Australia; it is consequently difficult to gauge their possibilities, as little reliable or authentic information is available. Thanks to the Commonwealth Meteorological Bureau having faithfully kept records of the rainfalls and the temperatures at a limited number of stations in both districts, one is, however, enabled to form a very fair estimate of their normal climatic conditions. At the same time, if we exclude the coastal strip of country that lies between Cairns and Townsville, and which is, for Queensland, comparatively thickly populated, it appears improbable that either Northern Queensland or the Northern Territory will produce any appreciable quantity of cotton for many years to come.

Northern Queensland.—Diagram No. 10 embraces the Peninsula, the Carpentaria and the North Coast Districts of Queensland; or that stretch of country to the north of latitude 20° S. The average rainfall for the above areas, compiled from the records of five stations situated at widely separated points, amounts to 39·67″ annually. The rainfalls

of coastal stations such as Cairns and Cookstown have been purposely omitted, as they apply to purely local areas on the seacoast where the precipitation is exceptionally heavy, and are not therefore applicable to Northern Queensland as a whole.



As Palmerville roughly forms the central point of the three districts under consideration, and as the temperature records of this station extend over a fair period of years, these temperatures have been used and may be taken as broadly representative for Northern Queensland.

Rainfall, temperature and humidity figures relating to Diagram No. 10 will be found in the table on p. 143.

The Northern Territory.—In regard to the Northern Territory, full information has been collected by the writer, but he has

DATA RELATING TO DIAGRAM NO. 10. NORTHERN QUEENSLAND.

Altitude and Rainfall.

Place.	Altitude in Feet.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mein	400	25	13·57″	11·04″	9·12″	3·35″	0·38″	0·24″	0·08″	0·11″	0·06″	0·60″	2·57″	6·25″	47·37″
Normanton	36	41	10·81″	10·24″	5·85″	1·66″	0·42″	0·31″	0·17″	0·09″	0·07″	0·56″	1·86″	6·17″	38·21″
Palmerville	689	23	11·77″	9·22″	8·18″	2·59″	0·45″	0·44″	0·16″	0·13″	0·46″	1·00″	2·41″	6·87″	43·68″
Georgetown	990	41	8·53″	8·15″	5·14″	1·58″	0·34″	0·46″	0·29″	0·15″	0·32″	0·82″	1·86″	5·94″	33·58″
Thornborough	...	29	9·28″	7·64″	6·14″	2·77″	0·43″	0·41″	0·23″	0·24″	0·34″	1·10″	1·53″	5·42″	35·53″
Average	...	32	10·79″	9·26″	6·89″	2·39″	0·40″	0·37″	0·19″	0·14″	0·25″	0·81″	2·05″	6·13″	39·67″

Temperature and Humidity.

Palmerville.	Number of Years Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean.
Mean Max. Temp.	15	90·8°	90·3°	89·7°	89·4°	87·2°	85·4°	85·6°	87·2°	91·6°	94·6°	95·6°	93·9°	90·1°
,, Min. Temp.	15	73·3°	72·9°	71·6°	68·0°	63·8°	59·8°	58·6°	58·6°	62·8°	67·0°	70·2°	72·3°	66·6°
Mean Temperature	15	82·0°	81·6°	80·6°	78·7°	75·5°	72·6°	72·1°	72·9°	77·2°	80·8°	82·9°	83·1°	78·4°
Rel. Humidity %	14	72	71	72	66	64	64	61	58	51	54	54	63	62·5%

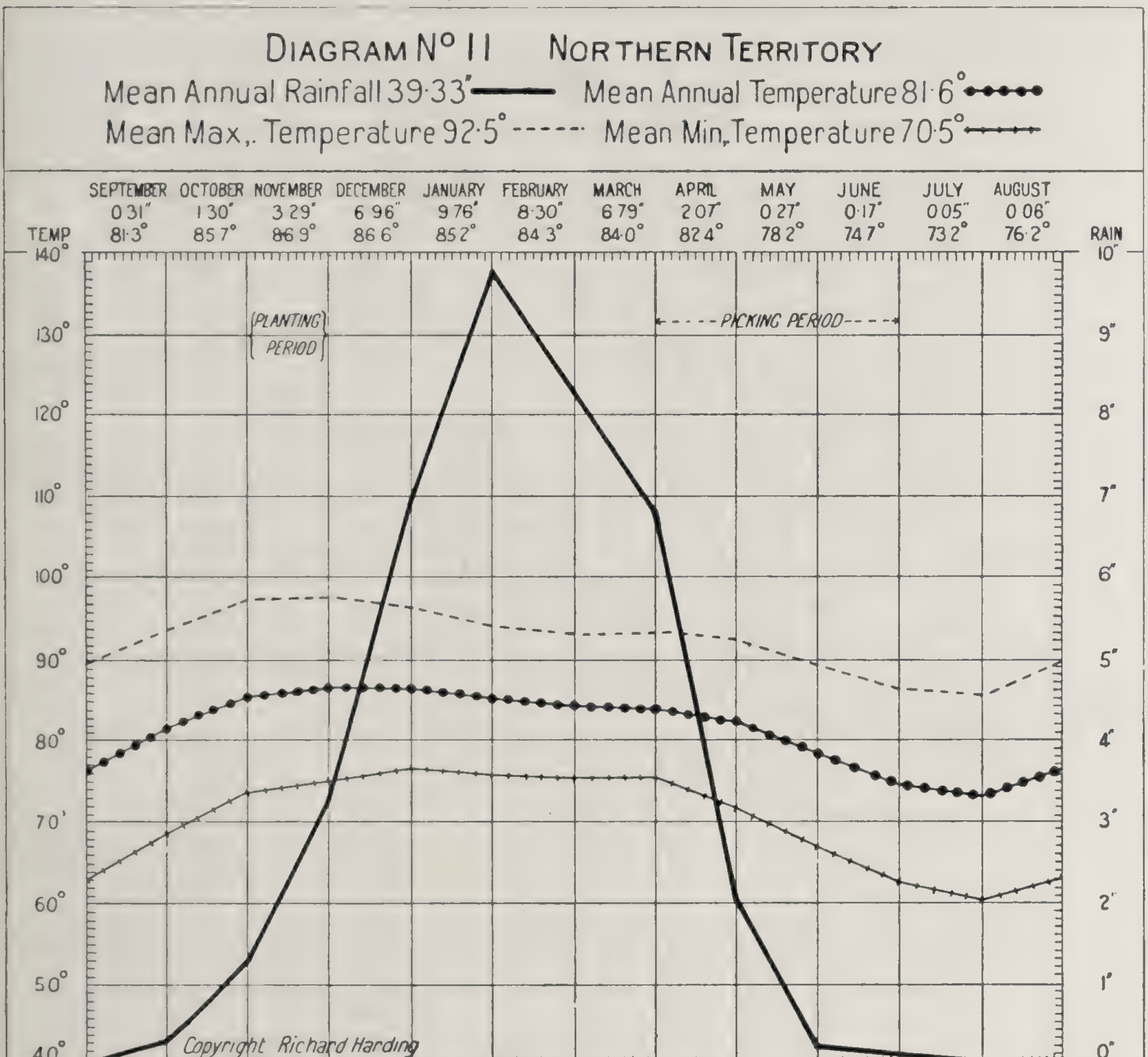
thought it better not to cumber a book, the intention of which is definitely practical, with data which—however interesting—cannot become of practical value until a very great increase takes place in the rural population. The number of white inhabitants of the Territory in 1921 was given as 2407, to which should be added some 1000 coloured people (Malay, Chinese, &c.), and an estimated aboriginal population of round about 20,000. The whites are mainly engaged in cattle raising or mining and the Chinese and Malays in pearl fishing: the number of people who are at present engaged in farming is most remarkably small. The aborigines, whilst prepared to assist in purely pastoral pursuits such as boundary riding and rounding up cattle, have a general disinclination for any form of manual labour and should not be counted on to any extent for the cultivation of cotton.

Suffice it to say, therefore, that—as will be seen from Diagrams Nos. 10 and 11—the sowing of cotton in the northern regions of Australia must be governed entirely by rainfall: in the case of Northern Queensland, *November 30* is indicated as the optimum date, in the case of the Northern Territory *November 15*. As a matter of fact, the climate of Northern Australia appears to bear, in many respects, a remarkable resemblance to that of the great cotton belt of Central India, viz., the Central Provinces, Hyderabad and the Deccan.

The high percentage of humidity and the warm, even climate are conducive to the growth of fungoid diseases, and possibly these may form the greatest obstacle that cotton will have to contend with in these areas. They will call, therefore, for special varieties of cotton that are resistant to such diseases and are capable of withstanding the torrential rainfall frequently experienced during the months of January and February, when the plants would be in flower, and when violent precipitation would be detrimental to ordinary varieties. Care will have to be taken, also, to avoid water-logging of the soil.

According to the Evans Report on the Cotton Growing Possibilities of the Northern Territory, dated August 23, 1923, much of the coastal belt, where the rainfall is heavy, consists of sour, hungry and rather infertile land, often underlain by a clay-pan at shallow depth and consequently water-logged during the wet summer season. Many of the coastal alluvial lands also appear to be too swampy for successful cotton growing; but there are numerous small areas of suitable and fertile soil, as is the case in the neighbourhood of Stapleton,

along the banks of the Adelaide River, and in the Grove Hill-Mount Bonnie area; together with pockets of fine soil adjacent to the Margaret River and Saunders Creek. Of the inland areas, the Katherine district appears to be the most suitable for cotton, as here the rainfall is not so heavy (39·37″)



and the land is better drained. There also appear to be very considerable expanses of fertile and well-drained alluvial soils round about Mataranka, eighty-five miles south of Katherine; in the neighbourhood of Waterhouse Creek and along the upper reaches and tributaries of the Roper River.

During the 1922–23 season experimental cotton plots were grown at several places in the Northern Territory and gave the following yields per acre: Mataranka, 1350 lb. of seed cotton; Pine Creek, 1000 lb.; Stapleton, 600 lb. (of the Acala variety). It should be remembered that the foregoing

were the results of small plots, and cannot therefore be taken to represent true 'field' yields. A small saw-ginning plant is being erected at Darwin to deal with the crop of 1923–24.

Samples of 1922–23 Northern Territory Acala, and of cotton grown from 'Queensland Seed' at Thursday Island,

BOTTLE TREES GROWING IN QUEENSLAND SCRUB. THESE TREES ARE NOT USUALLY DESTROYED WHEN THE LAND IS CLEARED FOR CULTIVATION, BUT ARE ALLOWED TO REMAIN STANDING, AND ARE FELLED IN TIMES OF DROUGHT. THE INTERIOR OF THE TREE IS SOFT AND SPONGY, AND IS READILY EATEN BY STOCK WHEN GRASS IS SCARCE.

off the northern extremity of Cape York Peninsula, were submitted to the writer. The Northern Territory Acala gave a staple of $1\frac{1}{8}$ inch and was of good quality and strength, being

very much superior to cotton produced from similar seed grown under irrigation along the River Murray in South Australia. The Thursday Island cotton was also of good quality, colour and strength, but the staple, although fine, was of uneven length, varying from $1\frac{1}{16}$ to a bare $1\frac{3}{16}$ inch.

The Pink Boll Worm (*Gelechia gossypiella*) is universally present throughout the possible cotton-growing areas of the Northern Territory, and may be expected to cause a certain amount of damage. This worm has not been found in Queensland or New South Wales, and these States are taking stringent measures to prevent its possible introduction.

Summary.—It would appear that both the Northern Territory and the northern districts of Queensland are capable of producing cotton of excellent quality, but a good deal of experimental work will be necessary to determine the varieties of cotton, the types of soil and the spacing that are best suited to these regions. Any large-scale production is, however, impossible until there is a great increase in the population.

PART II.—WESTERN AUSTRALIA

Western Australia embraces the entire western part of the continent and stretches from latitude 14° S. to 35° S. For the purposes of cotton growing, this State may roughly be divided into three districts, viz.:

(1) The South-West, or Perth-Albany district.
(2) The Central Area, or Geraldton-Carnarvon region.
(3) The Kimberley District, including Broome, Derby and Wyndham, together with the inland areas extending as far south as Hall's Creek.

The South-West.—This district extends as far northward as latitude 30° S., and is the most thickly populated part of Western Australia, as it includes the towns of Perth and Albany. It appears practicable to produce quick-maturing American Upland varieties in this region, as there is a sufficient period for growth between the dates of the first and last frosts; but as it comes within the belt of winter rains irrigation during the summer months will be necessary. This must greatly add to the cost of production, making it rather doubtful whether it will be profitable to grow cotton by itself.

In the Perth area the majority of the land consists of

light sandy soils that do not appear to be particularly suitable for cotton, as, if good crops are to be produced, these soils, in addition to irrigation, will also require heavy manuring. The best lands, consisting of red loams, are already occupied by fruit orchards, and it would seem that the cultivation of cotton in the South-West will be mainly confined to the growing of this crop as an adjunct to fruit.

One or two small experimental plots were grown during 1922–23, but no particulars are available as to the cost of production, the yield per acre or the quality of the cotton.

The Central Area.—This may be taken to include all that tract of country that lies between latitude 18° and 30° S., of which the most important townships are Geraldton, Carnarvon and Onslow. This district is altogether unsuited to commercial cotton production by reason of its exceedingly small rainfall and extremes of temperature. North of Geraldton frosts do not occur, but very high summer temperatures prevail, the thermometer going up to 120° Fahrenheit.

The rainfall throughout the Central Area is utterly inadequate: the annual precipitation on the coast in the vicinity of Carnarvon and Onslow amounts to only about seven inches, and decreases to less than five inches over inland areas. In the northern portion of this region the fall is but slightly greater, averaging about 13½ inches annually, and even though the precipitation occurs in the summer months it must prove quite insufficient for cotton.

The soils are, in the main, of too light, sandy and hungry a nature for the successful cultivation of cotton; they are naturally deficient in plant food, and will require heavy applications of manure if they are to be made to produce full crops. The few small experimental cotton plots that were grown under irrigation in 1922–23 failed to give good yields, as the plants matured too rapidly and were dwarfed in consequence.

If cotton is to be grown in this region it can only be under irrigation, and any irrigation scheme must entail a very heavy capital expenditure: most of the rivers are dry during the greater part of the year, and very large storage accommodation would have to be provided to cope with the irregular floods that occur. The water rates would be high in consequence, and it seems very doubtful whether cotton could withstand the expense.

The Kimberley District.—This may be said to embrace the tract of Western Australia to the north of latitude 18° S., all

Cotton Planted between Rows of Young Vines.

of which comes under the influence of the summer monsoons and receives an annual rainfall varying from 20 to 27 inches in the south to about 50 or 60 inches in the north. The character of the monsoons in the southern part of this region differs essentially from that of the rest of Northern Australia: they come principally in the form of local thunderstorms (known as ‘ Cock-eyes ’), that give good local rain over a small area but do not generally spread over large areas of country hundreds of miles in extent, as is the case in Queensland. The result is that, whereas in true monsoonal regions the air temperature is lowered and remains cool and damp for a considerable period after a good rainstorm, this effect is not apparent in the southern and the western portions of the Kimberley District: for, owing to the local nature of these thunderstorms, there is no appreciable cooling of the atmosphere over a large area, with the result that hot dry air is speedily drawn in from the surrounding country and much of the good effect of the rain is lost. Plants growing on light sandy soils under the above conditions will have a very trying time and will be liable to be scorched.

In the northern portion of the Kimberley District the rainfall seems to be slightly more reliable and more widely distributed, approximating in type to that of the true monsoon. When fuller information is available concerning this little-known part of the continent, it will probably prove that the climatic conditions of the northern extremity of Western Australia are generally more suitable for tropical agriculture than is the case in the vicinity of Broome and Derby. Experiments carried out by the mission stations on the Drysdale River and on Camden Sound appear to have successfully demonstrated that good cotton can be grown under natural rainfall in this area.

Kimberley District—Pindan Soils.—Much of the land in the neighbourhood of Derby and Broome consists of very light, red, sandy loams that are known as Pindan Soils. These have next to no subsoil and are extraordinarily porous; they show practically no signs of clay or silt, and even when wet they will readily crumble; the result is that a few hours after a heavy shower of rain the surface is dry and dusty.

They also appear to be rather lacking in fertility, as they carry but a moderate quantity of native gums or other trees, and these are mostly of inferior size. Numerous white ant hills of huge dimensions occur on this land, and wherever these

are seen throughout Australia they may be taken as a fairly sure sign of poor country. In tropical regions having an annual rainfall of 30 inches or upwards it is usual to find a certain amount of undergrowth, but such is not the case on Pindan soils, as the undergrowth consists almost entirely of deep-rooted perennial grasses, and even the clumps of these are frequently separated from one another by patches of bare soil several feet in extent ; this would seem further to indicate that the soil is not naturally fertile.

Analyses of Pindan soils given in 'The Nor'-West and Tropical North' (Despiessis) not only show these soils to be very deficient in nitrogen, but also in lime, phosphates and probably potash. In fact, the red Pindan sands are not really suitable for cotton ; and this is borne out by the fact that the few experimental cotton plots grown on this type of country have given unsatisfactory results.

Kimberley District—Black Soils.—Very large areas throughout the Kimberleys consist of Black Soil Plains, noted for their flatness and the fact that they carry no timber. These soils are fine, deep, black clay loams, with any amount of substance. They have the appearance of being very fertile, and usually carry a fairly heavy crop of annual weeds and grasses. In wet weather such country might prove difficult to cultivate, and it is perhaps on the heavy side for cotton. A detailed survey, however, would probably reveal large areas of land where these black soil plains mingle with the Pindan sands and result in a loam of fair constituency, which should prove to be the type of soil best suited for cotton. In some localities, during the wet season, these black soils become too marshy and water-logged to be of any use for cotton ; but where the land is provided with natural drainage they hold out far better prospects for successful production than the sandy Pindan soils.

The Pink Boll Worm has been found in the vicinity of Broome and seems to have been introduced with imported Caravonica seed : since its arrival it has been able to survive in the perennial trees that have been grown in this district. This pest is also reported to have been discovered near Derby, and, although this report lacks definite confirmation, it may quite likely prove to be correct.

Summary.—In conclusion, it would appear that a little cotton may be expected to be produced in the South-West, either as a catch-crop or in conjunction with fruit farming,

while the Central Area holds out little hope for the production of commercial crops, owing to the necessity and high cost of irrigation.

The Kimberley District is the only area in Western Australia where cotton may be grown solely under natural rainfall, and will almost certainly prove to be the only region in which commercial crops may be ultimately produced. Experimental work in this district is necessary before any attempt is made to produce large crops, not only in order to arrive at some idea of the cost of production, but also to determine the varieties that are most suited to the various climates and localities. This does not apply to cotton alone, but also to other tropical crops suitable for rotation with cotton.

RAINFALL AT BROOME DURING THE GROWING SEASON

Season.	November.	December.	January.	February.	March.	Total.
1916–17 . .	...	...	32·56″	0·70″	2·86″	36·12″
1917–18 . .	...	4·73″	4·97″	15·31″	0·21″	25·22″
1918–19 . .	...	2·68″	2·60″	16·49″	1·86″	23·63″
1919–20 . .	1·31″	7·28″	4·90″	0·92″	5·05″	19·46″
1920–21 . .	2·04″	7·83″	0·47″	6·83″	9·80″	26·97″
1921–22 . .	0·50″	0·29″	0·11″	10·77″	0·45″	12·12″
Average . .	0·64″	3·80″	7·60″	8·50″	3·37″	23·91″

Even in the Kimberley District there is an element of doubt, as, especially throughout the southern portion, the rainfall is erratic and spells of hot dry weather may be expected to occur at any period of the growing season.

Serious attention would also have to be given to the selection of suitable land, and the heavier black soils, although possibly too heavy in their present state, might be made suitable for cotton if they were thoroughly cultivated and were provided with open surface drains. Applications of gypsum or lime, together with fallowing and the ploughing-in of green manure, would probably do much to make them more friable.

As is the case in Northern Queensland and the Northern Territory, the production of cotton in the Kimberley District is limited by the lack of population, the whites only numbering from five to six thousand and the blacks about five thousand.

The bulk of the information given above relating to Western Australia has been obtained from a report on the

cotton-growing possibilities of that State, made by G. Evans to the Honourable the Minister for the North-West, Perth, W.A., dated February 26, 1923.

The rainfall at Broome (Kimberley District) during the growing season for the years 1916–17 to 1921–22 is given herewith, and shows the unreliability of the precipitation. The heavy rainfall during January 1916–17 is largely accounted for by the phenomenal downpour that took place on January 7, 1917, when the gauge recorded 14·00 inches in twenty-four hours.

The above figures indicate that in the Broome area it would be somewhat risky to sow cotton before the end of November, and that, in fact, the crop should be planted as soon as possible in *December* after the first good fall of rain has saturated the ground.

PART III.—IRRIGATION AREAS

As far as the present-day production of cotton in Australia is concerned, the irrigable areas consist of the lands adjacent to the River Murray and its tributaries, the Darling, the Lachlan and the lower reaches of the Murrumbidgee River. Almost all the country in the vicinity of these rivers receives an annual rainfall of less than 20 inches, and is situated either on the approximate dividing line between the belts of the winter and the uniform rains, or else in the region of the winter rains, thereby necessitating the irrigating of cotton, if this crop is to be grown successfully.

The Murrumbidgee Irrigation Area of New South Wales has already been dealt with in Chapter V, and the water rates are favourably low. Elsewhere in Australia very different conditions prevail, as, almost without exception, the irrigation water has to be pumped up from the rivers at high cost.

The Darling River in New South Wales may, for all practical purposes, be regarded as unsuitable, owing to the irregularity of its flow, to its susceptibility to forming new channels, and to its inundation of the surrounding country when it comes down in flood. Further, as the Darling traverses the far inland districts, land in its vicinity is subjected to extremes of temperature and, during the summer, to hot parching winds that would prove detrimental to the cultivation of cotton.

The Lachlan River presents more favourable conditions. This river has its source amidst the tablelands of New South

Wales, where uniform rains occur, and possesses a flow that is comparatively even throughout the year, so that land in its neighbourhood is seldom flooded to any great extent; also it does not experience violent extremes of temperature.

Several small plots of American and Egyptian (Pima) varieties of cotton were grown under irrigation along the Lachlan during 1922–23, and in both cases produced cotton of very good quality. Especially was this the case with crops grown near Lake Cargelligo, but, as these plots were nothing more than experimental patches of small area, it has been impossible to obtain even an approximate estimate of what the cost of irrigating the crop by means of water pumped from the lake amounted to. Judging by the samples of cotton, however, the Lake Cargelligo district, and probably many other areas along the Lachlan River, appear to be fully capable of successfully producing cotton under irrigation; but whether the value of the crop will exceed the cost of producing and transporting it by rail for 300 miles to the ginning factory on the sea-coast remains to be proved.

Murrumbidgee River.—The lower reaches of the Murrumbidgee River are climatically suited to the production, under irrigation, of quick-maturing American varieties, at those places in its immediate vicinity where suitable land is to be found. Unfortunately, much of the country is either too hilly, or rises too steeply from the river, to permit of any appreciable area being irrigated satisfactorily, and cotton cultivation must be mainly confined to the river flats.

River Murray.—The main Australian irrigation areas are situated on either side of the River Murray in the States of Victoria and South Australia. These Murray lands consist of a strip of fairly thickly populated country along the river banks, and, as a certain amount of cotton has been grown in these districts during the last two seasons, we have, in this instance, a little actual experience to work upon. It is therefore proposed to deal rather fully with the River Murray area, as the knowledge gained of growing cotton in this region should act as an index to other irrigation districts in Australia having corresponding conditions.

For the purposes of irrigation, the Murray lands may be divided into two distinct groups, each presenting totally different aspects, both as regards the nature of the soil and the cost of irrigation, viz.:

(1) The upper reaches, where the Murray runs between

cliffs and banks of rich loamy alluvial soils, and where water for irrigating has to be pumped up from the river to the land above. This system of pump-irrigation is to be found at such places as Berri, Redcliffe and Renmark, and holds good, with very few exceptions, from Swan Hill to almost as far downstream as Murray Bridge.

(2) The lower reaches, that extend from just above Murray Bridge to near the mouth of the river, where the land on either side of the Murray consists of reclaimed swamps, of remarkable fertility, which lie below the level of the river. These areas are protected by dykes, and are irrigated by gravitation, or free-flow, the drainage water being eventually pumped back into the river.

In view of the necessarily higher cost of producing cotton under irrigation than under natural rainfall conditions, the cultivation of Egyptian varieties was first attempted, as this type of cotton is of the greater value, and also because it was thought that the climate of the Murray Valley resembled that of Egypt. This latter idea is only in part correct, for, whereas there is a similarity between the spring temperatures of these two countries, the growing season along the Murray is very much shorter than that of the Nile Delta. The Murray summer and more especially autumn temperatures are appreciably lower than those of Egypt: as a natural sequence, slow-maturing Egyptian varieties have been unable to produce full crops in the States of Victoria and South Australia.

Temperature records for representative places on the Murray such as Renmark, Morgan, or Murray Bridge are not available, and it has only been possible to obtain those of Wentworth, near Mildura. The Wentworth temperatures are almost identical with those of the Murrumbidgee Irrigation Area, and as the two former places and the upper reaches of the Murray have apparently similar climates, and are in more or less corresponding latitudes at the same distance from the coast, the Murrumbidgee temperatures illustrated in Diagram No. 4, Chapter V, may also be taken as representative for the Murray area in general. What has been said with regard to the unsuitability of the Murrumbidgee Irrigation Area for the production of Egyptian varieties will therefore apply with equal force to the areas along the River Murray.

The irrigated lands adjacent to the upper reaches of the river consist of rich, red, loamy soils, which are very retentive of moisture and are exceedingly fertile. The great majority

of the country that is at present under cultivation is devoted to fruit farming, and it is on this class of land that most of the cotton has been grown during the last two seasons, either as an interplanted crop between fruit or vines, or else on small areas by itself. Although there are slight variations between the soils of different localities, the country is in general fairly uniform and, as Renmark approximately occupies the central point of this region, the results of cotton experiments carried out by the South Australian Department of Agriculture at Berri Experimental Orchard, near Renmark, can be taken as fairly representative for the upper reaches of the River Murray.

Berri Variety Test, River Murray.—During the 1922–23 season, numerous types of cotton were tested at Berri, on open land having a gentle slope towards the river, and were given only three irrigations during the season. This variety test was restricted to two rows of each variety, the rows being 3 feet 6 inches apart and 190 feet in length, equal to about ·03 acre.

It is proposed to first of all deal with the growth of the different varieties, and afterwards to treat of the quality of the fibre produced.

Pima.—Germinated very well and gave the most vigorous growth; the plants were upright in habit and reached a height of from 36 to 50 inches, but were too long in maturing. Approximate yield 938 lb. of seed cotton per acre.

Sakellaridis.—Germinated well; the plants stood erect and were from 18 to 30 inches high, but appeared to be somewhat stunted in growth and failed to mature properly. Estimated yield 300 lb. of seed cotton per acre.

Hartsville 12.—Gave good germination, but the plants, which stood from 15 to 24 inches high, were inclined to be bushy or spreading, and gave an approximate yield of 800 lb. per acre.

Brown's No. 4.—Germinated well and produced plants of erect growth, from 15 to 24 inches in height, yielding at the estimated rate of 800 lb. of seed cotton per acre.

Allan's Improved Long Staple.—Germinated satisfactorily, the resultant plants being of a fairly robust and vigorous character, from 24 to 30 inches high. Approximate yield 733 lb. per acre.

Webber 49.—Gave a very fair germination. The plants were strong and bushy, with numerous bolls of large size. The cotton matured early and was easily picked, as it came

away readily from the boll ; the plants attained a height of from 24 to 30 inches. In the field, Webber 49 stood out from the other varieties owing to the sturdiness of the plants, the number of bolls, and its early maturing properties. Approximate yield 933 lb. of seed cotton per acre.

Acala.—Germinated well, and also appeared to show good promise in the field, maturing about the same time as Webber 49. The plants were of a bushy nature, reaching from 30 to 42 inches in height, and gave an estimated yield of 1533 lb. per acre.

Delta Type.—Germinated satisfactorily and produced medium bushy plants, standing from 24 to 30 inches high. This variety also matured early, and gave an approximate yield of 1133 lb. of seed cotton per acre.

Lightning.—Germinated poorly and gave rather disappointing results, the plants being only from 18 to 24 inches in height and not of robust growth ; neither did they mature as early as Webber 49. Estimated yield 700 lb. per acre.

Durango.—Germinated well and gave promise of being a very good variety for the River Murray areas. The plants were of medium growth and of a bushy nature, attaining a height of from 24 to 36 inches, the yield being estimated at 733 lb. per acre.

Sunbeam Long Staple.—Gave a good germination and produced fairly strong-growing plants, which reached a height of from 24 to 40 inches ; the approximate yield was placed at 800 lb. of seed cotton per acre.

The writer was not fortunate enough to see these varieties growing in the field, but samples of most of the cottons produced were forwarded to him for an opinion as to their quality and characteristics. The samples were received and reported on previous to his having had any indication as to how the plants had behaved during growth.

Extracts from the official report submitted by the writer to the Honourable G. F. Jenkins, Minister for Agriculture in South Australia, on the results of the Berri Variety Test, are given herewith :—

' In order to pass an absolutely unbiassed opinion on these ' cottons, they were subjected to the " blind test," that is, ' the samples were all arranged so that the names of the ' varieties were hidden, and the cotton had therefore to be ' judged purely and simply on its merits. As a further pre- ' caution, when I had classified the samples for the first time

'and had made a note as to their order of merit, all samples 'were changed round during my absence from the room, and 'were then reclassed over again. In each case my original 'opinion was confirmed, and I give you herewith my opinion 'on these samples in their order of merit:

'*Webber* 49, *Strain* 4, from Berri Experimental Orchard. '—An exceedingly fine and very good quality cotton, far and 'away the best of the American varieties submitted to me, 'with a silky, lustrous and very fine fibre, eminently suited 'for the spinning of fine counts and mercerisation; closely 'resembling the finest of white Egyptian cottons. Length 'of staple, $1\frac{3}{8}$ to $1\frac{1}{2}$ inch, and a clear, creamy white in colour.

'*Durango*.—A strong, wiry cotton, or what is technically 'known as a hard or tough cotton, and very much finer than 'Queensland samples of Durango grown under natural rain-'fall this season. Length of staple, $1\frac{3}{16}$ to $1\frac{1}{4}$ inch. Colour, 'creamy. (A little bit off in colour.)

'*Delta Type*.—A fine, long, and good-coloured cotton, '$1\frac{1}{4}$ to $1\frac{1}{2}$ inch in length, but soft in staple and lacking in 'strength; hence my reason for classing it as inferior to 'Durango.

'*Acala* from Cobdogla, *Acala* from Berri Orchard, *Harts-'ville* 12 from Berri Orchard.—These three varieties are very 'similar and are of a soft and irregular staple, somewhat 'lacking in lustre, and decidedly lacking in strength. Length, 'from $1\frac{1}{16}$ to $1\frac{3}{16}$ inch.

'Of the foregoing American varieties, I have no hesitation 'in saying that Webber 49, Strain 4, is undoubtedly much 'the most superior, but in each and every case the cotton 'contains a greater percentage of waste than should be present. 'I presume that this is due to the fact that all the crop has been 'gathered and that the pickings have not been kept separate.

'*Egyptian Varieties*.—With the exception of the cotton 'taken from Mr. Fisher's special plant, which was picked 'after the plant had been uprooted, all samples show a very 'marked improvement over the finest Pima cotton grown 'along the Murray last year (Hubank's crop at Renmark, '1921–22).

'*Pima*—first picking Cobdogla Plantation.—A clean, 'very fine long cotton, averaging $1\frac{5}{8}$ inch in length, more even 'in length of staple than was the case last year, but not yet 'as strong and wiry as true Egyptian cotton. Colour, creamy 'brown.

'*Sakellaridis.*—Very similar to true Egyptian cotton, and 'shows a marked improvement over the sample submitted to 'me last year, but is not as strong as the same variety when 'grown in Egypt. Length of staple, $1\frac{1}{2}$ inch. Colour, a rich 'cream.

'Conclusions.—Summarising the whole position, and taking 'all things into consideration, it would appear as if Webber 49 'is best suited to your localities, as this, in addition to being 'a fine, long-stapled cotton, nearly as long as Egyptian cotton, 'requires a shorter growing season, and is easier to pick, 'thereby greatly reducing the cost of production; and, judging 'by the quality of the fibre, Webber 49 should realise very 'nearly as much as Egyptian varieties on the Liverpool market. 'While recommending that Egyptian varieties should still be 'cultivated, such cultivation should be reduced to a few experi-'mental plots, and the bulk of your activities should be centred 'on American long-stapled varieties, such as Webber 49.'

Although the foregoing experiment was only the result of one season's observations, there seems to be no doubt that the River Murray is not suited to the commercial production of Egyptian varieties. This was indicated in the first place by a comparison of Egyptian and Murray temperatures, and has since been verified by the behaviour of the plants themselves. Further, small-bolled Egyptian types can never be popular in Australia, owing to the difficulty and the length of time required to pick the crop.

The Murray season is of ample length and seems to be in every way suited to the production of fine, long-stapled American varieties, the product of which is nearly as valuable as that of Egyptian cottons. American seed should be sown during the beginning of the month of October, as soon as danger of frost is past.

American types have many advantages, for not only can they be picked quickly and easily, but the cost of production in the field is also lessened owing to the fewer number of irrigations required, as the period of growth is shorter than that of Egyptian varieties.

Even though Webber 49, Strain 4, grown at Berri, did not give as great a yield as either Acala or Delta Type, it is very interesting to note that both the grower and the classifier judged it to be most suited to the River Murray. Whether or not it will maintain this marked superiority during future seasons can only be proved by experience.

The irrigable lands bordering the lower reaches of the river consist almost entirely of reclaimed swamps and, when mention is hereafter made of the lower reaches, it is to be taken to apply to these swamp-lands alone, and not to country above the water level of the Murray. These swamps are for the most part to be found on either side of the river, and vary in width from half a mile to a mile and a half. The soil is in reality pure peat, formed from decayed rushes and vegetable matter, and is of amazing richness, the present-day value of reclaimed swamps being in the neighbourhood of £50 per acre.

Although the cost of irrigating these lower reaches is less than for the upper reaches of the Murray, there are three good reasons why cotton is not likely to be extensively grown along them :

(i) The swamps are too rich.
(ii) The cash return obtainable from cotton compares unfavourably with that from other crops.
(iii) Difficulty is experienced in forcing cotton to ripen off its crop.

During 1922–23, two one-acre plots were grown on reclaimed swamp-land—by the Hon. J. Cowan just above Murray Bridge, and by Messrs. Morphett at Woods Point, some considerable distance down-stream from the former place. These crops behaved in a very similar manner, and thereby enable one to draw certain conclusions.

In both cases, the plants developed excessive vegetative growth and produced a relatively small number of bolls for their size. This may be attributed to the extraordinary richness of the soil, as it is a well-proven fact that cotton gives better yields on medium soils than on those that are exceedingly rich.

The second point of interest was that both these plots failed to give a full crop, as the plants refused to ripen off their fruit. The bushes remained green and continued to flower and to form new bolls until the plants were killed by the cold autumn weather ; yet, only three irrigations were given—one before planting and two during the period of growth.

These swamp-lands are drained by means of open ditches to a depth of about four feet, the drainage water being delivered back into the Murray by centrifugal pumps that have to be

kept in almost continuous operation if they are to cope with the seepage water that percolates through the peaty soil from the river. It seems evident that the cotton roots reached the sweet subsoil water four feet below the surface (the tap root would easily penetrate to much more than this depth in soft soil) and the plants continued to draw their moisture from the subsoil, even though no further surface irrigations were applied. This would certainly account for the plants remaining green and forming new bolls late in the season, instead of ripening off their crop.

The only solution of this problem would seem to be to make the surface drains eight feet deep, and to keep the level of the water at four feet below the surface until after the final irrigation, when the drains should be pumped dry. This sudden reduction of the subsoil water to a depth of eight feet would deprive the plants of most of their moisture, and should result in forcing the crop to mature.

The Murray swamp-lands are mainly devoted to the growing of lucerne, a crop that not only gives a greater return per acre in this district than cotton, but also entails proportionately less labour. These very rich peaty soils are naturally conducive to vegetative growth and are therefore eminently suited to lucerne, which yields as many as six or seven cuts in a season. It is interesting to note that the difficulty experienced by cotton in maturing is also experienced by lucerne, as the latter, if left uncut, develops rank growth and attains a great height; but the seeds will not ripen, and sowing seed has to be imported from other regions when it is necessary to replant a field.

For the foregoing reasons it does not appear probable that any very great quantity of cotton will be cultivated along the lower reaches of the Murray.

Estimated Cost of Production under Irrigation.—It is only possible to form an approximate estimate of the cost of production under irrigation, as no accurate details have been kept of the expenses incurred. The estimate that is given hereafter applies only to the upper reaches, where the altitude of the land varies from 20 to 60 feet above the river level. The water-rates consequently vary from £3 to £7 per acre, according to the height of the irrigated land and the distance that the water has to be pumped. Some soils are not so retentive of moisture as others and, whereas only three irrigations were necessary at Berri, other soils may

require five ; an average of four waterings may perhaps be taken as the mean number that are required to bring a cotton crop to maturity along the upper reaches of the Murray. In non-irrigated districts the cost of cultivation is much less than in irrigated areas, as with the latter a cultivator or plough must be used to furrow-out before each irrigation, and the cultivator used again after the watering to pulverise the ground. Where the water-rates are high, or where the land has a natural slope, it is impracticable to flood the entire field, as is done in Egypt and other parts of the world. As the Murray lies within the belt of winter rains, there are long periods throughout the summer when no rain occurs and constant tillage of the land is necessary to conserve the moisture in the soil. The basic agricultural wage in this district is 13*s.* per day, as against 11*s.* in Queensland.

Estimated Cost of Production under Irrigation

Yield of 1000 *lb. of seed cotton per acre.*

	£	*s.*	*d.*
Two ploughings	1	16	0
Three harrowings	0	8	0
Planting	0	4	0
Chipping and thinning	0	12	0
Six cultivations	1	0	0
Labour for irrigating, making furrows and harrowing after irrigation	1	10	0
Water-rate	4	10	0
Cost of picking 1000 lb. of seed cotton at 1½*d.* .	6	5	0
Bagging and cartage	0	15	0
Interest on value of land (£14) at 6% . .	0	17	0
Total Cost of Field Production . . .	£17	17	0
Value of 1000 lb. of seed cotton at the Government's guaranteed price of 5½*d.* per lb. . .	£22	18	4
Net Profit to grower per acre . . .	£5	1	4

Summary.—The Governments of Victoria and South Australia have given growers similar guarantees to those given by the States of Queensland and New South Wales, and also pay the ginning and freight expenses. Should the cotton when

sold realise more than the guaranteed advance ($5\frac{1}{2}d.$ per lb. for seed cotton or $16\frac{1}{2}d.$ per lb. for lint) plus the freight, ginning charges, etc., then any surplus is returned to the growers, *pro rata* with those who supplied the cotton. Fine long-stapled American Upland varieties grown adjacent to the Murray should realise nearly the same price as Egyptian cotton, which is to-day worth approximately 23*d.* per lb., in which case the grower would eventually receive a surplus of about £4 3*s.* 4*d.* This figure, added to the profit made on the Government's advance, would bring the net profit per acre up to *£9 4s. 8d.*

The production costs along the lower reaches would be appreciably less, as there are no water-rates, and the grower has only the expense of pumping the drainage water back into the river. Further, the peaty soil is very retentive of moisture and requires fewer irrigations, whilst, as the entire field is flooded when it is necessary to irrigate, there is not the cost of making furrows. Despite these lower costs, cotton does not give as big a cash return as lucerne, and on the whole appears unsuited to the lower districts.

The upper reaches, however, have proved that they can produce long-stapled American Upland cotton of the very finest quality, and appear to be able to make a commercial success of such varieties, either when grown as a lone crop, or, more particularly, when cultivated as an adjunct to fruit.

CHAPTER VIII

SOILS AND SOIL ANALYSES

Formation of soils—Composition of rocks—Sedimentary, metamorphic and igneous rocks—Classification of soils—Analyses of American soils—Egyptian soils—New South Wales soils, Coastal districts—New South Wales soils, North-western inland districts—Queensland soils, Series No. 1, Cairns—Series No. 2, Mackay—Series No. 3, Bundaberg.

In the various cotton-producing countries of the world the plant is grown upon a great variety of soils, ranging in texture from light loose sands to heavy plastic clays ; and, although it may be almost impossible to define exactly what constitutes the ideal cotton-growing soil, it is generally admitted by all authorities that a fairly rich, deep and well-drained sandy loam is the type of soil best suited to the requirements of the plant. Whilst the nature of the soil plays an important part in the successful cultivation of cotton, it is not of such importance as a suitable temperature and rainfall, as without the latter the crop cannot be produced, no matter how suitable the soil. Whereas the climate of one country may be readily compared with that of another, it is a more difficult task to compare soils, owing to their complex nature and to the fact that different countries frequently employ dissimilar methods of analysis, thereby rendering it possible to draw only rough conclusions in comparing the soils of other countries with those met with throughout the Australian cotton belt. Before turning to this subject, it may be well to give a rough summary of the principal classes of soils, together with the types of rocks from which they originate.

Formation of Soils.—Rocks close to the surface of the earth undergo a continual process of decomposition and disintegration due to the combined effects of changes of temperature, wind and rain ; this process of decay is known as 'weathering.' The weathering of rocks is the result of physical and chemical causes, of which the most important are sudden changes of

temperature, water in the form of rain or as running creeks, wind, and the action of vegetation.

Any sudden change of temperature results in the expansion or the contraction of the rocks and causes a gradual loosening of the crystals of which they are formed. This is most marked if the temperature falls below the freezing point of water, as a certain amount of moisture is almost invariably present between the rock crystals, or in crevices, and, when frozen, expands and exerts a tremendous pressure, resulting in the breaking away of the crystals and the deepening and the widening of the fissures. Water, either in the form of rain or as running streams, has a twofold effect, physical and chemical. The physical action consists in the gradual wearing away of the rocks as the water passes over them, or else through the friction of stone upon stone as occurs in river beds. Water by itself has also a distinct chemical action, dissolving many of the minerals of which the rocks are composed, and this action is considerably increased by the absorption of carbonic acid from the atmosphere.

Wind also possesses a mechanical action, which is increased by particles of sand and stone being blown against the exposed surfaces of the rocks.

When that soil has been formed vegetation occurs ; and when once plant life is established, then the decomposition of the rocks proceeds at a much greater pace, as the roots of the plants act both physically and chemically on the stones or rocks with which they come in contact. The fine hair-like roots find their way into the minutest fissures and enlarge them as they grow, thereby admitting air and water which further helps to disintegrate the rocks. Plant roots have also a powerful chemical solvent action, due to the acid liquid secreted in their tips which, when it comes in contact with the mineral substances of which many rocks are composed, has a dissolvent effect upon them.

Very briefly stated, the foregoing are the primary causes of the formation of soils, and it follows as a matter of course that the fertility of the soil must depend to a great extent upon the variety of rock from which it originated.

Composition of Rocks.—Rocks may be broadly divided into three main classes :

1. Sedimentary Rocks.
2. Metamorphic Rocks.
3. Igneous Rocks.

Sedimentary Rocks.—As the name implies, sedimentary rocks are composed of sediment, or the dissolved particles of other rocks which were at one time suspended in either sea or fresh water, but which have settled in layers upon the beds of the oceans or inland seas and have in course of time hardened and again turned into rock, through the enormous pressure of more recently deposited matter and the chemical action of one or several substances contained in the sediment. Sedimentary rocks embrace limestones, sandstones and claystones.

Under the heading of limestones are also included chalks and marbles, as the foregoing are largely formed from decomposed shells or the skeletons of various organisms. Soils derived from limestones are in nearly all cases fertile and rich in plant food ; lime being one of the essentials for plant life.

Sandstones may be roughly divided into five groups, and in general form light, poor, sandy soils, which in some cases contain only the merest traces of plant food ; but the quality of the soil varies in relation to the type of sandstone from which it has been derived. Thus calcareous sandstones yield a very much better class of soil, which, in fact, is frequently of the very best.

Claystones give heavy, clayey soils that are almost invariably rich in the ingredients of plant food, but are frequently too heavy and sticky to be readily cultivated.

Metamorphic Rocks may very roughly be defined as sedimentary rocks that have undergone an alteration due to the effects of subterranean heat, so that they assume a crystalline or semi-crystalline structure. Thus limestones become transformed into marbles of various degrees of purity according to the composition of the original rocks. Sandstones when cemented by silex are transformed into quartzite,a common rock that is usually white, grey or rusty in colour. Claystones and rocks when subjected to the metamorphism of subterranean heat produce a great number of varieties of metamorphic rocks due to the varying ingredients of which clay rocks are composed, of which the most common are granites, gneiss, hornblende and syenite—a rock composed of feldspar and hornblende.

Igneous Rocks are volcanic or eruptive rocks that have been erupted from the heated interior of earth in a molten state. Igneous rocks are usually divided into two groups—quartz and basalt. The former is characterised by a big percentage of free quartz (silicic acid) and is generally of a light

tint and crystal formation, being quite colourless when pure. Basalt, on the other hand, is usually of a dark colour, due to the presence of a large amount of iron in its composition, and soils derived from basalt are in general very fertile.

Classification of Soils.—Soils may broadly be divided into four main groups :—

Sandy or light soils, possessing 80 per cent., or over, of sand.
Loams or medium soils, having about 50 per cent. of sand, the balance consisting of clay, humus and lime.
Clays or heavy soils containing 70 per cent., or over, of clay.
Peaty or humic soils possessing from 20 per cent. to 80 per cent. of vegetable or organic matter.

Various authorities differ in their classification of soils. Hilgard, when dealing with the clay content of American soils, approximately designates them as follows :—

Very sandy soils .	0·5 to 3	per cent. clay
Ordinary sandy lands	3·0 to 10	,, ,,
Sandy loams . .	10·0 to 15	,, ,,
Clay loams . .	15·0 to 25	,, ,,
Clay soils . .	25·0 to 35	,, ,,
Heavy clay soils .	35·0 to 45	,, ,,

Brünnich, when treating of Australian soils, gives the following practical farmers' classification :—

Nature.	Stones.	Sand.	Clay.	Lime.	Humus.
Stony soils .	80% and more	...	...	...	...
Sandy soils .	...	80% and more	...	...	...
Sandy loam .	...	50 to 80%	20 to 50%	under 2%	...
Loam . .	...	...	50 to 70%	under 3%	...
Clayey soil .	...	10 to 30%	50 to 70%	under 2%	...
Clay . .	...	...	70 to 95%	under 3%	...
Marl . .	...	...	20 to 50%	5 to 20%	...
Calcareous soil .	...	...	...	20 to 50%	...
Peaty or humic	...	...	...	...	20% and more

Humus may briefly be defined as decayed vegetable or organic matter, and has a most important bearing on the soil, for it is remarkable how close is the relation between the

Scrub Land, near Bundaberg, Queensland.

humus content of a soil and its fertility. According to Brünnich, humus contains 44 to 50 per cent. of carbon, 6 to 10 per cent. of nitrogen, 3 to 6 per cent. of hydrogen, 28 to 35 per cent. of oxygen, and 4 to 12 per cent. of ash containing chiefly potash, soda and phosphoric acid.

The principal soil ingredients consist of sand, clay, humus and lime. Of these humus is probably the most important, for it has far-reaching influences on both the chemical and the physical properties of the soil. Humus will render a sandy soil coherent or a sticky soil friable ; it is retentive of moisture and supplies food for bacteria, thereby promoting nitrification of the soil. Briefly, humus in the soil has a similar effect to yeast in dough : it leavens and aerates the whole.

American Soils.—In the United States of America cotton is grown on practically all well-drained types of soils, ranging in texture from light loose sands to heavy plastic clays, but the extremes of texture are not desired for moisture conditions or ease of cultivation. In general, upland soils give low yields of cotton, as also do the heavy clays and some bottom lands during wet seasons, though these latter produce large vegetative growth. In normal seasons the most productive American cotton soils are the dark-coloured clay lands, especially those rich in lime, and the brown, red, and black well-drained river bottom lands ; some of the best yields are obtained upon the heavy, calcareous clays of West Texas. Most of the cotton in the United States is grown upon the sandy loams of the coastal plains, a considerable amount upon the well-drained river bottom land and second bottom alluvial soils, and some upon limestone country. The sandy loams of the coastal plains are mainly grey or mellow brown in colour, with a yellow or red friable sandy clay or clay subsoil, for the most part admirably drained, easy of cultivation and retentive of moisture, but lacking in plant food.

On these soils, and in the eastern portion of the cotton belt, the extensive use of fertilisers results in a relatively high yield of cotton being obtained on thin, sandy land, and permits of the growing of a crop on types of soil which would otherwise give yields too low to be profitable.

The following table shows the results of the chemical analysis of certain types of soil that constitute some of the important cotton soils of the United States. These analyses are made from soil material less than 2 mm. in diameter and not of the parent material.

CHEMICAL ANALYSES OF IMPORTANT U.S.A. COTTON SOILS

Formation.	Soil Type.		Nitrogen per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Granite . Gneiss . Schist .	Cecil clay loam	soil .	0·053	0·051	0·439	0·27
		subsoil	0·021	0·085	0·342	0·19
	Cecil sandy loam	soil .	0·027	0·018	1·40	0·081
		subsoil	0·023	0·02	2·85	0·121
Diorite . Diabase . Gabbro .	Davidson clay	soil .	0·09	0·34	0·37	0·24
		subsoil	0·02	0·28	0·31	0·23
Selma chalk or soft limestone	Houston black clay	soil .	0·17	0·15	1·44	11·31
		subsoil	0·14	0·17	1·16	21·98
		lower subsoil	0·05	0·09	0·55	42·27
Sandstone . Shales .	Hanceville silt loam	soil .	0·07	0·10	0·67	0·05
		subsoil	0·03	0·11	1·06	0·13
Consolidated	Norfolk sandy loam	soil .	0·03	0·02	0·297	0·197
		subsoil	0·08	0·01	0·11	0·30
Coastal plain	Greenville sandy loam	soil .	0·12	0·02	0·35	0·38
		subsoil	0·03	0·07	0·32	0·17
Material .	Marlboro' sandy loam	soil .	0·04	0·06	0·23	0·22
		subsoil	0·02	0·18	0·20	0·30

One very noticeable feature in the foregoing table is the large amount of lime in the Houston black clay, particularly in the subsoil, and more especially in the lower subsoil which represents the parent material in a practically unweathered condition. There is also a close resemblance in the analyses of the sandy loams of Norfolk, Greenville and Marlboro'; these and associated soils cover a large part of the cotton belt and, while they are low in elements of plant food, they have been made to produce high yields of cotton through fertilisation and crop rotation.

Much of the information relating to American soils has been obtained from Soil Survey Reports issued by the United States Department of Agriculture, and the author is greatly indebted to both Mr. William Whitney, Chief of the Bureau of Soils, and to Mr. O. E. Baker, Agricultural Economist, Bureau of Agricultural Economics, U.S.A. Department of Agriculture, Washington, for the personal interest and help they have so courteously extended.

Egyptian Soils.—The following soils relate to the Nile Delta of Lower Egypt, which consists of alluvial soil brought down by the Nile. Full details of the physical and chemical analyses of these soils are given in Appendix I. The soil of

the Nile Delta is, in general, very well suited to the production of cotton and, with the exception of the West Indian Sea Islands, portions of the South-Eastern States of America and the coastal belt of Queensland, Egypt produces the finest cotton in the world, and is to-day the only country that exports any large quantity of fine long-stapled cotton. As the Nile Delta is composed of alluvial deposits, there is a fair degree of uniformity between the soils of different localities, but even so, variations in texture occur and a blackish medium loam, such as is found in many parts of the province of Menufia, is considered to be better suited to cotton than the heavier or lighter types of soil met with in other parts of the Delta.

CHEMICAL ANALYSES OF EGYPTIAN SOILS

District.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime per Cent.
Qalioub . .	0·060	0·27	0·80	4·38
Tantah . .	0·061	0·22	0·63	2·44
Mansourah .	0·107	0·19	0·63	3·82
Damanhour .	0·093	0·31	0·89	3·88

A further point of interest with regard to cotton in Egypt is that there is a direct connection between the salt content of the soil and the strength of the fibre produced by the plants. A small, and as yet undefined, percentage of salt is beneficial and increases the strength of the fibre ; but if the salt content is above a certain amount it becomes very detrimental. Consequently land in the vicinity of Sakha and other districts of the north of the Nile Delta has to be continually washed in order to prevent it from becoming surcharged with salt that rises from the subsoil. The presence of brackish water in the subsoil, which is particularly noticeable in the northern portion of the Delta, is due to lack of drainage and to the low altitude of the land.

It will be noticed that Egyptian soils are somewhat deficient in nitrogen ; this deficiency is fully recognised by the Fellaheen (Egyptian peasants), and is rectified by the rotation of crops and the ploughing-in of green manure. It is the general practice in Egypt to grow a species of clover, called ‘ berseem,’ on land which it is afterwards intended to plant with cotton. Two or three crops of berseem are cut and used as green-feed for cattle, but the final crop, instead of being cut and harvested,

is ploughed under. This ploughing-in of berseem occurs some three months previous to the planting of cotton and greatly enriches the nitrogen content of the soil.

New South Wales Soils.—The following particulars relating to New South Wales have been obtained from a work by H. I. Jensen, D.Sc., entitled 'The Soils of New South Wales,' and from Government publications issued by the Department of Agriculture of that State. The various analyses have been summarised in table-form and have been divided into coastal and inland areas; details concerning the soils of the tablelands and the far inland districts have been excluded, as such localities are unsuited to cotton. Figures in brackets in the 'Formation' column denote the number of soil samples used in arriving at the analysis of that particular place or district.

The most noticeable difference between the soils of the coastal and the inland districts, as shown by the tables on pp. 173–175, is to be found in their respective nitrogen content. The inland districts, although well up in lime, are rather deficient in nitrogen; this is a defect that may be easily rectified by the rotation of suitable crops, by good cultivation and the imparting of humus to the soil, or else by the application of fertilisers.

Queensland Soils.—The analyses of Queensland soils given on pp. 176 and 177 are taken from the May, June, July and August issues of the Queensland *Agricultural Journal,* 1923, issued by the Department of Agriculture and Stock, Brisbane, Queensland. The figures were prepared by Mr. George R. Patten, Analyst, Agricultural Laboratory, Brisbane, formerly Chief Chemist, Bureau of Sugar Experiment Stations.

The soils have been divided into three series, dealing respectively with the districts of Cairns in the northern portion of Queensland, Mackay in the central district of Queensland and Bundaberg in the southern portion of that State.

Each of the above-mentioned districts has been subdivided into subdistricts as follows:—

Series No. 1. Cairns.—Mossman River, Cairns, Johnstone River and Herbert River.

Series No. 2. Mackay.—Burdekin Delta, Proserpine and Mackay.

Series No. 3. Bundaberg.—Bundaberg, Goodwood, Isis, Logan, Maryborough and Moreton.

SOIL ANALYSES.—N.S.W. COASTAL DISTRICTS

Formation.	District.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Basaltic (36)	North Coast	0·222	0·226	0·073	0·168
Slate (17)	,, ,,	0·189	0·223	0·068	0·126
Limestone (3)	,, ,,	0·224	0·091	0·105	0·399
Sandstone (8)	,, ,,	0·103	0·055	0·063	0·060
Alluvial (4)	Northern Rivers	0·241	0·154	0·153	0·291
Slate (6)	,, ,,	0·274	0·094	0·092	0·149
Volcanic basaltic (68)	,, ,,	0·249	0·199	0·087	0·167
Volcanic chocolate (22)	,, ,,	0·286	0·175	0·098	0·042
Alluvial (15)	Hastings, Hunter, and Manning	0·293	0·174	0·087	0·316
Basaltic (16)	,, ,, ,,	0·265	0·179	0·122	0·318
Sandstone (2)	,, ,, ,,	0·119	0·077	0·112	0·130
Basaltic (12)	South Coast	0·418	0·218	0·074	0·264
Slate (5)	,, ,,	0·175	0·040	0·142	0·088
Sandstone (35)	,, ,,	0·207	0·109	0·078	0·100
Granite (18)	,, ,,	0·395	0·288	0·109	0·119
Alluvial (3)	,, ,,	0·079	0·072	0·102	0·089

SOIL ANALYSES.—N.S.W., NORTH-WESTERN INLAND DISTRICTS

Formation.	District.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Basaltic	North-Western Slopes	0·142	0·294	0·119	0·456
Black soils (23)	,, ,, (Moree)	0·066	0·092	0·286	0·714
Sandstone (10)	,, ,, (Pilliga Scrub)	0·053	0·076	0·044	0·067
Dark loam	North-Western Plains (Narrabri)	0·098	0·237	0·192	0·725
Basaltic (9)	Central Western Slopes	0·078	0·145	0·176	0·340
Red soils (6)	,, ,, ,, (Parkes)	0·097	0·153	0·161	0·321
Granite (14)	Central Western Slopes and Plains	0·083	0·126	0·190	0·304
Triassic sandstone (2) . . .	Central Western Plains (Narromine)	0·115	0·137	0·107	0·135
Black soils (2)	,, ,, ,, (Coonamble)	0·110	0·154	0·264	0·476
Red soils (12)	,, ,, ,, (,,)	0·067	0·146	0·190	0·243
Red soils (13)	,, ,, ,, (Nyngan)	0·066	0·160	0·263	0·231

AVERAGE COMPOSITION OF NEW SOUTH WALES SOILS

Coastal Districts

Formation.	District.	Moisture, per Cent.	Volatile, per Cent.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Alluvial	North Coast (Manning)	4·77	10·13	0·258	0·152	0·158	0·442
,,	,, ,, (Rivers)	2·88	9·75	0·241	0·154	0·153	0·291
Sandstone	,, ,, (Manning)	1·81	5·34	0·119	0·077	0·112	0·130
,,	,, ,, (Clarence)	0·64	3·70	0·103	0·055	0·063	0·060
Slate	,, ,, (Rivers)	4·22	11·02	0·274	0·091	0·092	0·149
All formations (294)	North Coast	6·29	13·18	0·256	0·178	0·086	0·173
All formations (129)	South Coast	5·18	10·36	0·231	0·125	0·086	0·217

Inland Districts, excluding Tablelands

Formation.	District.	Moisture, per Cent.	Volatile, per Cent.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Basalt	North-Western Slopes	5·66	9·83	0·142	0·294	0·119	0·456
Alluvial	,, ,, (Namoi)	5·45	6·36	0·099	0·201	0·390	0·680
All formations (75)	,, ,,	5·74	7·69	0·112	0·185	0·239	0·559
Granite (14)	C.W. Slopes and Plains	0·89	5·21	0·083	0·126	0·190	0·304
Slate	,, ,,	2·10	4·45	0·086	0·145	0·095	0·147
Basalt (9)	,, ,,	2·91	6·33	0·078	0·145	0·176	0·340
All formations (100)	,, ,,	2·28	4·75	0·086	0·125	0·133	0·359
All formations (31)	Western Division	3·49	4·51	0·068	0·175	0·351	0·478
All formations	Murrumbidgee Irrigation Areas	...	6·50	0·040	0·150	0·450	0·600
All formations	All Inland Districts	3·65	5·55	0·088	0·146	0·242	0·473

AGRICULTURAL ANALYSES OF QUEENSLAND SOILS

Series No. 1

District or Place.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Cairns (Mossman)	0·127	0·11	0·53	0·26
Kamerunga (near Cairns) . .	0·097	0·14	0·28	0·17
Hambledon (near Cairns) . .	0·124	0·15	0·47	0·28
Mulgrave (Gordonvale) red soils .	0·127	0·22	0·40	0·32
Mulgrave (Gordonvale) alluvial soils	0·113	0·16	0·40	0·27
Geraldton (Innisfail) red soils .	0·173	0·27	0·17	0·08
Geraldton (Innisfail) alluvial soils .	0·165	0·23	0·26	0·13
Mourilyan	0·164	0·08	0·21	0·20
Halifax (Herbert River) . .	0·112	0·13	0·24	0·49
Ingham	0·087	0·14	0·19	0·32
Ripple Creek	0·106	0·12	0·24	0·46

AGRICULTURAL ANALYSES OF QUEENSLAND SOILS

Series No. 2

District or Place.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Homebush (Mackay) . . .	0·074	0·19	0·16	0·49
River Banks (Mackay) . . .	0·093	0·14	0·15	0·64
North Eton	0·075	0·12	0·20	0·63
Plane Creek (forest lands) . .	0·178	0·08	0·12	0·78
Plane Creek (scrub lands and low flats)	0·130	0·11	0·15	1·43
North of River and Farleigh . .	0·180	0·29	0·35	1·26
Sunnyside (Mackay) . . .	0·170	0·18	0·23	0·88
Proserpine	0·147	0·18	0·17	0·78
Burdekin	0·107	0·18	0·34	0·95

AGRICULTURAL ANALYSES OF QUEENSLAND SOILS

Series No. 3

District or Place.	Nitrogen, per Cent.	Phosphoric Acid, per Cent.	Potash, per Cent.	Lime, per Cent.
Isis (level lands)	0·189	0·24	0·18	0·35
Isis (hillsides)	0·183	0·29	0·16	0·39
Woongarra	0·221	0·40	0·14	0·64
Bingera (red soils)	0·137	0·20	0·19	0·36
Watawa	0·185	0·19	0·16	0·35
Gin Gin (forest lands) . . .	0·126	0·17	0·18	0·68
Gin Gin (river flats) . . .	0·150	0·23	0·34	1·01
Birthamba	0·149	0·21	0·08	0·26
Sharon, Kalbar, Oakwood, Bonna .	0·119	0·12	0·19	0·54
Fairymead	0·133	0·48	0·47	0·51
Waterview	0·153	0·14	0·45	1·11
Avondale (including Miara) . .	0·229	0·28	0·33	0·47
Invicta	0·206	0·22	0·23	0·36
Gooburrum	0·129	0·13	0·12	0·17
Pialba	0·193	0·15	0·14	0·20
Nerang	0·199	0·29	0·31	0·65
Mount Bauple (red soils) . .	0·140	0·17	0·10	0·32
Mount Bauple (grey soils) . .	0·170	0·18	0·18	0·26
Beonleigh	0·169	0·29	0·26	0·84
Moreton	0·197	0·12	0·19	0·44
Goodwood	0·168	0·19	0·13	0·44

The following summary includes the average analyses of Hatton (Mackay) and Alton Downs (Rockhampton) soils :

AVERAGE ANALYSES OF HATTON (MACKAY) AND ALTON DOWNS (ROCKHAMPTON) SOILS

	Total Elements in Soil.				Available Elements in Soil.		
	Lime, per Cent.	Potash, per Cent.	Phosphoric Acid, per Cent.	Nitrogen, per Cent.	Lime, per Cent.	Potash, per Cent.	Phosphoric Acid, per Cent.
Hatton (Mackay)	0·615	0·235	0·203	0·154	0·1112	0·0046	0·0024
Alton Downs (Rockhampton)	1·520	0·325	0·166	0·150	0·4616	0·0072	0·0038

AVERAGE ANALYSES OF HATTON (MACKAY) AND ALTON DOWNS (ROCKHAMPTON) SOILS—*continued.*

	Total Pounds per Acre.				Available Pounds per Acre.		
	Lime.	Potash.	Phosphoric Acid.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Hatton (Mackay)	22,487	6,600	6,525	3,800	3,170	192	57·5
Alton Downs (Rockhampton)	38,000	8,125	4,650	3,750	11,540	180	95

The Hatton soils compare favourably with those of other districts. In regard to total elements they are for the most part well up to standard, though the available potash is rather low. This, however, is a matter which may improve on cultivation, as the total amount is quite up to standard and apparently only requires to be made available.

The following examples are given—first, on account of their general value, showing the wide differences in the chemical composition of 'good' and 'bad' soils; and secondly, because of special examples which accentuate the great difference described, and show the essential need of soil analyses:

TYPICAL EXAMPLES OF GOOD AND BAD SOILS FOR COTTON OR ANY OTHER KINDS OF AGRICULTURAL CROPS

Soil.	Total Elements in Soil.				Available Elements in Soil.		
	Lime, per Cent.	Potash, per Cent.	Phosphoric Acid, per Cent.	Nitrogen. per Cent.	Lime, per Cent.	Potash, per Cent.	Phosphoric Acid, per Cent.
Good . .	0·916	0·344	0·188	0·103	0·1650	0·0344	0·0078
Bad . .	0·210	0·250	0·160	0·173	0·0087	0·0049	0·0003
Wallum .	0·063	0·061	0·072	0·042	0·0097	0·0036	0·0012

ELEMENTS PER ACRE TO THE DEPTH OF ONE FOOT

	Total Pounds per Acre.				Available Pounds per Acre.		
	Lime	Potash.	Phosphoric Acid.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Good . .	27,480	10,320	5,640	3,090	4,950	1,032	234
Bad . .	6,200	7,500	4,800	5,190	261	147	9
Wallum .	1,575	1,525	1,800	1,050	243	90	30

Forty-two Acres, all Cotton Land. Messrs. Bloomfield and Croft, "Bariveloe," Miriam Vale, Queensland.

AVERAGE AGRICULTURAL ANALYSIS OF COMPOSITE SAMPLES OF SOIL

Locality.	Moisture, per Cent.	Volatile Matter, per Cent.	Insoluble Residue, per Cent.	Chlorine, per Cent.	Phosphoric Acid, per Cent.	Ferric Oxide, per Cent.	Alumina, per Cent.	Lime, per Cent.	Magnesia, per Cent.	Potash, per Cent.	Soda, per Cent.
Mossman, Hambledon, Mulgrave (alluvial)	1·717	6·029	74·653	0·003	0·136	4·122	8·940	0·271	0·435	0·481	0·180
Innisfail, Mourilyan, Halifax, Ripple Creek, and Ingham (alluvial)	2·808	7·696	71·644	0·003	0·164	5·414	10·941	0·324	0·472	0·240	0·152
Innisfail and Mulgrave (bastard red soils)	3·444	13·182	50·953	0·004	0·264	13·009	18·592	0·159	0·256	0·248	0·157
Mackay, Proserpine (alluvial)	2·349	6·760	79·013	0·004	0·174	3·969	5·932	0·753	0·520	0·200	0·207
Burdekin (alluvial)	2·334	6·139	80·439	0·004	0·187	3·414	5·166	0·958	0·734	0·348	0·144
Isis level lands soils (volcanic)	2·558	11·255	53·943	0·003	0·247	14·336	16·726	0·344	0·277	0·186	0·092
Woongarra, Bundaberg (volcanic)	3·733	13·985	43·641	0·004	0·407	15·267	21·613	0·604	0·329	0·139	0·130
Bingera (red soils)	1·965	8·436	69·210	0·009	0·201	6·548	12·842	0·365	0·177	0·187	0·114

The table opposite represents the average agricultural analyses of composite samples of soil from the districts between Bundaberg and Mossman, also the relative solvent action of various acids upon such composite samples.

The soil analyses given in this chapter clearly demonstrate the general fertility of the soils met with throughout the cotton belts of New South Wales and Queensland. If these Australian analyses are compared with those given for Egyptian and American soils, it will be seen that not only are the Australian soils well up to standard, but that in a great many instances they are appreciably richer in plant food than those of either of the two latter countries.

The figures speak for themselves and should dispel any doubts as to the suitability of Australian soils for the production of cotton.

CHAPTER IX

CONTROL OF SEED SUPPLY

Need of uniformity in cotton—Pure strains—Mendel's Law—Advantages of pure strains—Hybrids—Natural crossing—Mixture of seed at ginnery —Mixture of seed by seed merchants—Selection—Rejection—Propagation of pure strains—Testing—Renewal of seed—Control of seed distribution.

Need of Uniformity.—Cotton is grown to be spun into yarn. If it spins good yarn it is good cotton ; if not, it is bad cotton, and no matter how big a yield the plants may give, or how perfect may be their immunity from insect pests, their product has little commercial value if it fails to spin satisfactorily.

Above and before all else the spinner demands uniformity, and insists that the cotton shall be strong, even and regular in staple ; also that the quality, regularity and other characteristics of the crop shall remain unvaried from season to season.

If this uniformity in production is to be attained it is essential that seed distribution should be controlled by one organisation, in order to ensure

(1) The maintenance of a pure seed supply.
(2) The distribution of only one variety of pure seed to the growers of any defined district.

In the past cotton was sometimes spoken of as the most variable of organisms, being regarded as a plant subject to variations in its growth and characteristics which it was deemed impossible to control. The deterioration which usually occurred in the yield or quality of lint of a variety was attributed to the variety itself rather than to external causes capable of regulation.

The cause of this variation and deterioration is not hard to discover—it lies in the facts that either the variety is not pure in the first instance, or else that, if originally pure, it has become contaminated by natural crossing or mixture of seed.

Pure Strains.—A 'pure line' or 'pure strain' may be defined as a series of plants whose descendants breed true to the stock from which they originate as long as the original purity of the strain is maintained.

The investigations of recent years have proved that, provided a pure strain is kept free from contamination or crossing from without, the characteristics of the plants and the quality of the lint remain uniform and unchanged under normal climatic conditions from year to year, thereby assuring a regularity in the product on which both growers and spinners can rely.

Extreme or exceptional climatic conditions experienced during an abnormal season may cause a falling off in the yield of a pure strain, or result in the quality of the lint being inferior to that of previous years, but this is not due to any alteration in the constitution of the plants themselves: on a return to normal conditions the pure strain immediately reverts to its original quality, the character of the plants and the lint remaining unaffected by the ordeal of a bad previous season.

There is nothing difficult in the production or isolation of a pure strain and there is no mystery connected with it. It may almost be said that neither great skill nor any knowledge of cotton or botanical science is required: the one essential is continuous, untiring, searching accuracy in dealing with the material.

Mendel's Law.—The isolation or breeding of any pure strain is governed by 'Mendel's Law.'

Gregor Mendel was an Austrian monk born in the year 1822. Like previous investigators he was struck by the regularity with which the offspring of certain hybrids reproduce the pure ancestral forms. He presumed that, owing to the complex nature of the cases previously studied, together with the lack of accurate statistics, the precise facts had never been ascertained. Accordingly he set himself the task of methodically and systematically working out certain cases from which every confusing or misleading element should, as far as possible, be excluded.

He chose varieties of a pea (*Piscum sativum*) as best suited to his purpose; one variety was between six and seven feet in height; the other was a dwarf averaging about one foot in height. He crossed them by artificially transferring the pollen from one to another and waited to see the result. The

offspring of this cross between the tall and dwarf varieties all grew into tall plants. It in no way affected the experiment whether the tall parent was a male and the dwarf a female, or *vice versa* ; their offspring always grew into tall plants. In this case the character *tallness* was supreme in the offspring, to the exclusion of the opposite character of *dwarfness* ; Mendel therefore called the strong or supreme character *Dominant* (D), while the weaker, disappearing or receding character he called *Recessive* (R). In modern terminology the hybrid offspring, the first filial generation, is called (F1) .

Mendel's next step was to self-fertilise these tall (F1) cross-breds. He then found that the plants resulting from them, instead of being uniform like their (F1) parents, proved to be mixed, some being short and the others tall, like their grand-parents. A definite ratio, however, was found to exist amongst this mixed and impure (F2) generation, viz. *three dominants* (3D) to *one recessive* (1R).

The next stage was to self-fertilise the (F2) generation, the offspring of each plant being sown separately. In the case of the dwarf (F2) recessives he found that the offspring (F3) were all dwarfs, and, what is more important, that thereafter these continued to breed true through any number of generations. In other words the recessives of the (F2) generation were not only apparently, but *actually* pure, had no taint of the cross and bred true to the recessive character of dwarfness.

In the case of the tall (F2) dominants, however, he found by a study of their offspring (F3) that while the parent plants had appeared to be pure dominants, they were in fact mixed—some pure, others impure dominants :

(*a*) One-third proved themselves to be pure talls, producing as their offspring only *tall* plants, or pure dominants, which when self-fertilised bred true in succeeding generations.

(*b*) Two-thirds proved themselves to be impure dominants, producing both tall and dwarf plants (dominants and recessives) in the ratio of 3 : 1.

$$\underbrace{\begin{array}{c}\text{25 \%}\\ \text{Pure Dominants}\end{array} \qquad \begin{array}{c}\text{50 \%}\\ \text{Impure Dominants}\end{array}}_{\begin{array}{c}\text{3 Dominants}\\ \text{(tall)}\end{array}} \qquad \underbrace{\begin{array}{c}\text{25 \%}\\ \text{Pure Recessives}\end{array}}_{\begin{array}{c}\text{1 Recessive}\\ \text{(dwarf)}\end{array}}$$

The descent may diagrammatically be represented thus ;

Tall (pure) × Short (pure) — Parents

Tall (impure) — F1

Tall (pure) | Tall (impure) | Tall (impure) | Short (pure) — F2

Tall (pure) | Tall (pure) Tall (impure) Tall (impure) Short (pure) | Tall (pure) Tall (impure) Tall (impure) Short (pure) | Short (pure) — F3

If the pure dominants are represented by D, the impure dominants by (D); the pure recessives by R, and the impure recessives by (R) it gives us:

Tall × Short — Parent

(D) — F1

D | (D) | (D) | R — F2

D | D (D) (D) R | D (D) (D) R | R — F3

It will be seen that the F2 generation is composed of two impure dominants (D); of one pure dominant D, and of one pure recessive R: these two latter breed true to type in all subsequent generations; but the two impure dominants continue to split up, producing four types of offspring similar to F2 generation.

In breeding pure strains of cotton, the isolation of these pure lines is rendered more difficult owing to the differences between the plants being less than that between the tall and the dwarf varieties of pea; the various characters of cotton are also more complex. According to Dr. W. L. Balls, F.R.S., these characters consist of:

Dominant.	*Recessive.*
Long staple.	Short staple.
Regular distribution.	Irregular distribution.
Coloured lint.	White lint.
Silky lint.	Harsh lint.
More fuzz.	Less fuzz.

Those who wish to go deeper into this subject should refer to 'The Cotton Plant in Egypt: Studies in Physiology and Genetics,' by W. L. Balls (Macmillan & Co., London); 'Mendelism,' by R. C. Punnett (Macmillan & Co.); 'Mendel's Principles of Heredity,' by W. A. Bateson (Cambridge University Press).

Advantage of Pure Strains.—The utility of pure strains consists in the following:

Uniformity.—Their product remains unchanged from year to year.

Reliability.—Given a normal season, the quality of the lint and the yield per acre can be approximately foretold.

Tracing Defects.—We know how a pure strain should behave and of what it is capable. If, therefore, a crop is not up to the standard of the strain, the fact can immediately be recognised and search made for the cause.

The pollution of a pure strain and its consequent deterioration are due to two primary causes:

1. Natural crossing in the field with the pollen of a foreign variety.
2. The immixture of foreign seed at the ginning factory, or by seed merchants.

Hybrids.—Either of the above causes will produce 'rogues' or hybrid plants, which may be defined as a cross between two different strains or varieties of cotton; the result being much the same whether this crossing takes place between two pure strains, or between a pure and an impure variety.

It is a proved fact that the descendants of a hybrid or impure strain of cotton are utterly unreliable. The quality and quantity of their yield cannot reliably be estimated, and the period of their growth to maturity cannot accurately be reckoned. The gravest defect of an impure strain, however, is its lack of uniformity in lint.

The defects of an impure strain are manifest in the plants themselves. If one glances over a mature field of hybrid cotton, it presents a jagged and uneven appearance to the eye; differences between the shape and characteristics of individual plants will be noticed, but more striking still is the variation in heights: some plants will be short and stumpy, others tall and rank.

Practically no well-known variety of commercial cotton is absolutely pure, and many 'rogues' may be picked out in

any field. One might think that if cotton is capable of being grown and marketed commercially, its staple must be approximately uniform, but such is not the case, for samples of what was the most uniform of Egyptian commercial cottons, taken from different mature plants of the same variety, from the same field, on the same day, revealed that the length of the lint oscillated from 25 to 33 millimetres, *i.e.* there was a variation of over $\frac{2}{10}$ inch between the longest and the shortest fibres. This variability of lint length between the fibres of a variety is at its maximum with hybrids and at its minimum with pure strains.

In the case of a certain pure strain of Egyptian cotton this oscillation in length of lint was from 31 to 34 millimetres, or a variation of less than $\frac{1}{10}$ inch ; the regularity of the lint and the purity of the strain having already been demonstrated by the evenness and similarity between the plants in the field.

Although it may be true that a hybrid, in the first year of its existence, may give a more prolific yield than that of either of the pure strains from which it was derived, it is equally true that it fails to maintain this superiority in future generations, and the subsequent falling off in yield, and the loss in regularity and strength of staple of its descendants, are so marked and rapid as to render the ultimate product almost worthless when compared with the value of the lint of either of the pure strains from which it originated.

It may, perhaps, be considered that undue stress is being laid on this subject ; but Australia has before her the experience of Egypt, where the following strains of cottons, Yannovitch, Abbassi, Assili and Afifi, which were once flourishing commercial varieties, are now almost extinct, owing to deterioration in quantity and quality directly consequent upon their having degenerated into hybrids. Sakellaridis, which at present is the principal variety grown in the Egyptian Delta, is not as good or as pure as it used to be, and it seems possible that the day is not so far distant when this latter variety may also have to be discarded.

If, however, we take the case of Ashmouni or 'Upper' cotton, grown along the banks of the Nile south of Cairo, where for climatic reasons no other type of cotton does so well, we find that during the last ten years this variety of cotton has suffered no marked deterioration, because, through its natural isolation, it has not been subjected to the natural

crossing experienced by other varieties which have been cultivated side by side in the Egyptian Delta.

It might very naturally be thought that if 5 per cent. or 7 per cent. of rogues were mixed amongst a pure strain they would not greatly affect it, as they form such a small percentage of the whole. This small amount of impurity would not be serious in itself, were it not for the ultimate effect produced on the pure strain. If the hybrids produced the same number of seeds per plant as the pure strain, no great damage would result, as their percentage in relation to the whole would remain unaltered and a small percentage of impurity could be pardoned. Unfortunately, however, hybrids are far more prolific than either of the strains from which they originate, and their presence within a pure strain must, therefore, result in their disproportionate increase. This applies very strongly to crosses between Upland and Sea Island or Egyptian cottons, and to crosses between Hindi-weed cotton and Egyptian; in extreme cases crosses between these latter have given four or five times as much seed as their neighbours which were pure strain plants. Consequently, the impure plants are disproportionately numerous in the next season's crop and result in a marked acceleration in the rate of contamination.

When dealing with the subjects of crossing, productivity of hybrids and the resultant contamination of pure strains, Dr. W. Laurence Balls, who is held by many to be the greatest living scientific authority on the breeding of pure strains of cotton, has said:

'The same holds good, even for crosses between two 'varieties of Egyptian, which may be very similar externally. 'The existence of natural crossing thus results, not merely 'in the formation of new, abnormal plants, but also in an 'abnormal increase of the proportion of such plants in the 'population. Statistical results have shown that the forma- 'tion of only 2 per cent. of neutral hybrids with other 'Egyptians, inside a pure strain of Egyptian cotton, may lead 'in three years to a conversion of 20 per cent. of the strain 'to rogues, without any further assistance by crossing from 'outside the strain.

'The deterioration of varieties from constitutional causes 'thus appears to depend on their initial impurity, on natural 'crossing within and from without, and on seed mixture from 'without.

'To prevent such deterioration, we have first to begin 'operations with pure strains, then to propagate those strains 'without permitting any natural crossing from without, and, 'lastly, to handle our seed so as to avoid mixture.'

Before turning to the investigation of natural crossing or cross-fertilisation, it is necessary to remember that where there is the greatest dissimilarity between the parents the quantity of the recombinations will be most numerous and complex ; and that the closer the similarity between the parents the easier it will be for crossing to take place. Whereas it does not appear possible for crosses between the Indian and the Upland or Peruvian groups to occur, it is, on the other hand, easy to cross artificially Uplands and Peruvians. It is an interesting fact that, although it is possible for Egyptian pollen to grow down an Upland style, if equal amounts of foreign and self pollen be placed on the style simultaneously the majority of the victors will be self tubes. If, however, pollen from a first-cross between Upland and Egyptian be placed on the Upland style simultaneously with self pollen, only just over half the conquerors will be self tubes. From this it will be seen that once crossing has commenced inside a pure strain it becomes a simpler matter for it to continue and increase, as the obstacles confronting the foreign pollen are progressively lessened. Should, however, the primary cross occur between different varieties of the same group the odds confronting the foreign as opposed to the self pollen are reduced at the outset and contamination will be increased correspondingly.

Natural Crossing.—Natural crossing in the field takes place to a greater extent than is generally believed. If the pollen is derived from another flower of the same plant or from that of a brother plant the result is the same as self-fertilisation. There is always the risk, however, that the pollen may be derived from a hybrid in the same field, or, what is worse still, from the flower of a totally different variety in an adjacent field. In the latter case crossing takes place giving rise to new hybrids or rogues. From 5 per cent. to 10 per cent. of the seeds grown in an Egyptian field are crossed in this manner. It is this difficulty of excluding foreign pollen which presents such a formidable obstacle to those who attempt to breed, or introduce, new varieties of cotton or to improve old ones.

The greatest offender in the transmitting of alien pollens is the bee. It will be readily understood that a bee, as he works his way down to the nectaries between the petals at the base of the flower where the honey is secreted, will rub pollen off the brush of the pollen sacs onto his back, and will automatically deposit this pollen on the style of the next flower that he visits. Beetles, butterflies and other insects are also offenders in this respect.

In most cases it is only the plants on the borders of a field that are contaminated in this way, for as the bee works his way from flower to flower towards the centre of the field the foreign pollen that he may have brought from another field is soon rubbed off his back ; but if, as in the case of ordinary commercial varieties, the field contains a fair percentage of hybrids, the bee will contaminate the pure strain plants from the hybrids which surround them. On seed-breeding farms this risk of contamination due to natural crossing in the field is minimised by not growing different varieties in proximity to one another and, as an additional precaution to guard against the damage liable to be caused by bees or other insects, the seed resulting from a marginal strip around the borders of the field is destroyed. (This subject is more fully dealt with on p. 198.)

Mixture of Seed at the Ginning Factory or by seed merchants is the second cause of the deterioration of a variety.

In the natural course all cotton grown in the vicinity of a ginning factory is delivered to it for ginning, and no matter how well the ginner may attempt to cleanse the gins, flue pipes and other machinery, it is certain that a small percentage of the seeds of the variety last treated will remain therein and inevitably become mixed with the seeds of the crop next dealt with.

During the ginning season the factories are working at full pressure, and it is impossible for the operatives, however willing, thoroughly to clean the gins without taking them to pieces ; the loss of time and money that such an operation would entail would be a serious consideration to the ginning factory. The result is that, in practice, gins are never thoroughly cleansed between the treatment of the crops of different growers. In addition, there is always the danger that a careless or inexperienced hand may mistake a sack containing one variety of seed cotton and mix its contents with another variety which is being treated ; by artificial light

Bee just about to enter the Flower of a Pima Cotton Plant (Egyptian Variety of Cotton).

during a night-shift, even an experienced man may make this error.

In Egypt, when no control is exercised over the distribution of seed and different varieties are permitted to be cultivated side by side, a great amount of natural crossing occurs in the field ; but even greater harm is caused by the mixing of seed that takes place in the ginning factories. The writer has seen more than one Egyptian factory deal consecutively with different varieties, without making an attempt to clean the gins or take any precaution to prevent mixture of seed.

It may, however, be of interest at this juncture to describe the minute care that is taken by the Egyptian State Domains (Government experimental and seed-breeding farms) to ensure that no mixing of the seed occurs at the gins under its control.

After the various varieties have been picked, the seed cotton is sacked in long bags, each containing approximately 400 lbs., and is transported to the seed-cotton house. This consists of a large store subdivided into numerous rooms or compartments, each capable of holding seed cotton equivalent to about fifty bales of lint. Throughout the store all floors are concreted and the entire building is carefully cleaned and swept before the arrival of the new season's crop. Different varieties of seed cotton are never permitted to enter the store at the same time, and the doors of all compartments, other than those allotted to the particular variety which is then being received, are kept shut and locked. The crops resulting from areas A, B and C in the field (see diagram, p. 198) are kept separate all the time. On arrival in their compartment the sacks are opened up and the seed cotton is stored in bulk. This bulk storage has a very beneficial effect, for it evens up the whole 'lot,' resulting in a thorough mixing of the seed cotton before ginning, thereby eliminating any slight variations between individual sacks. It has also been found that if the seed cotton is allowed to remain in bulk storage for at least three weeks it improves the quality of the lint and also greatly facilitates ginning. When all seed cotton of the specific variety has been received and stored, the doors of those rooms are closed and locked, and the corridors leading to them are thoroughly swept to remove any oddments of cotton which may have fallen from the sacks during transport from the carts into the store.

Before the ginning season commences the gins are taken

to pieces and thoroughly overhauled ; after they have been reassembled the entire factory building is minutely cleaned, and all seeds which may lurk in crevices of the machinery, cracks in the flooring, or corners of the building are thereby removed.

Ginning starts when the compartments in the store contain sufficient seed cotton to keep the gins working continuously. As the bulk of the cotton grown is of the Sakellaridis variety this is ginned first, the seed produced by areas A, B and C being ginned in alphabetical order. While the ginning of Sakellaridis is in progress no other variety of cotton is permitted to enter the building and, as all the compartments containing different varieties are kept locked, no mixing of seed or seed cotton can occur up to this point. Furthermore, no other variety is treated until the entire crop of Sakellaridis has been ginned. After the seed cotton produced by the marginal strip C has been ginned, the gins and their attendant machinery, together with the floors of the factory and the corridors leading from the store to the ginning hall, are carefully cleaned and swept, thus removing the great majority of Sakellaridis seeds.

It is, however, quite impossible thoroughly to strip and clean all machinery during the busy season, as the time required would be too great, and, despite the precautions taken, a very small percentage of Sakellaridis seeds must still remain hidden in various crevices and are certain to become mixed with the seeds of the variety next treated.

Let us presume that it is the intention to gin next a variety of brown cotton, such as Afifi. The procedure employed in the original instance is now reversed, for we know that in spite of all the care taken the gins are not absolutely free of cotton seeds, and that a certain amount of mixing between Sakellaridis and Afifi seed is bound to occur when ginning of the latter variety commences. Accordingly the seed cotton picked from C, the marginal strip surrounding the Afifi field —which is never distributed as sowing seed, as it is liable to be contaminated to a greater or less extent, owing to natural crossing—is first of all ginned. By its passage through the machines the cleaning process is completed and any remaining Sakellaridis seeds are removed. The fact of some mixing taking place at this stage is of no importance, as the seeds resulting from this ginning are destined to be crushed and destroyed. When all seed cotton from C, the marginal strip of Afifi, has been dealt with, the pure Afifi seed from the area

B is next ginned, and when the time arrives for the seed cotton from area A to be treated the gins should contain nothing but Afifi seeds, every trace of Sakellaridis seeds having been effectively removed. This method of cleaning and ginning is employed with all subsequent varieties, and is as nearly perfect as is humanly possible when a ginning factory has to deal with a number of varieties of cotton. In each case the varieties and qualities of seed are sacked and labelled immediately after ginning, and are then removed to their allotted stores.

In commercial practice, however, it is hardly to be expected that any ginning company would exercise such great care or take so much trouble as this.

Mixture of Seed by Seed Merchants.—If all and sundry merchants are allowed to sell cotton seed to the growers, and if the growers are allowed to plant any variety of seed which strikes their fancy, it follows in the ordinary course of business that the seed merchants must stock all varieties of cotton seed, in order to meet their clients' demands. If the merchant is unscrupulous and there is any difference between the price of the varieties he has in store, there is the risk that a flexible conscience may allow him to mix one variety with another, selling the whole at the price of the variety of greater value. Unless one is an expert in the subject it is a difficult matter to distinguish between the seeds of different varieties. And, even though the seed merchant be above suspicion, there is always the danger that through ignorance or carelessness on his part, or on that of his storekeeper, the contents of the open sacks of seed which he has in his store may become mixed. Seeds will become scattered upon the floor in lesser or greater quantities, and the chances are that whoever sweeps the floor may quite easily return these seeds to the first open sack, rather than throw them into the dustbin.

If seed so mixed by the seed merchant, or by the ginning factory, is used for sowing in the following season, impure seed is planted with pure seed, or seed of one variety with that of another, and impurity is imparted to the strain that it was desired to keep free from contamination.

The cotton produced by hybrids is not altogether worthless, and first-generation hybrids, in addition to their prolific yield, often produce a lint of surprising uniformity, frequently superior in quality to either of the strains from which they originated ; unfortunately this standard of excellence is not

maintained by future generations, and thus the great disadvantage of all hybrids lies in the fact that their seed is useless. Owing to the complex nature of the parent plant its offspring produce a very irregular lint and show a rapid decrease in yield, the consequent depreciation in value being in direct proportion to the percentage of hybrids which the crop contains. It would be to the advantage of the grower to destroy all such hybrid plants, even though they were not replaced, for their presence constitutes an element of loss which must recur with every season, as the labour employed in their cultivation and picking is the same as for that of cotton of higher value. It therefore follows that Australian farmers will obtain a great advantage when these hybrids are excluded from their crop and the supply of pure seed is controlled throughout the whole country under one system.

There are two methods by which an existing variety may be improved—Selection and Rejection.

Selection.—Selection in the field consists in picking out superior plants, or all those plants conforming to a specified standard. Continued selection amongst these superior plants may lead, and often does lead, to an increase in the proportion of the superior plants, and may in time even possibly result in the establishment of approximately pure lines; but this method of selection is fraught with many pitfalls, and no method of breeding cotton has greater possibilities of error and trouble than selection that is not practised intelligently. We have already laid stress upon the greater productivity of first-generation hybrids and on the superior quality lint they so frequently produce: herein lies one of the chief causes of error, for the choice of the superior plants in the field usually results in a selection of the most hybrid plants. It is only natural that the grower who is not conversant with botanical science should select these first-generation hybrids, which form the sturdiest and heaviest yielding plants in his field; and even though the selection is made on the basis of certain features, these may be due to environment and not to constitutional causes, in which case the labour expended is wasted, as the characters will not be inherited. At best, selection is a clumsy means of attaining our end, for it has the great disadvantage of not leading to uniformity in the crop, nor does it guarantee the purity of the strain, both of which are essential points.

The only advantage possessed by selective methods is

their rapidity, for by stringently adjusting our selection it is possible to collect enough seed in one year to meet the sowing requirements of the next. If used with discretion it may thus form a valuable stop-gap while the propagation of pure seed is in progress.

Rejection.—The method of rejection is safer and contains less chance of error than selection, for when it is remembered that hybrids are abnormal plants, differing in size and characteristics from the true strain, the risk of including these impure plants in our seed supply is reduced very greatly if we exclude all abnormalities from our choice. It is easier to reject non-typical plants than to select typical ones, for many which may be typical in two or three characters may yet be rogues in all the rest.

Both selection and rejection have to be continued year after year and, although such skilled work might perhaps be efficiently performed under the personal supervision of experienced botanists, it is admittedly beyond the capabilities of the ordinary cultivator, who, even though he should possess the necessary knowledge, may yet be unable to spare the time required.

The only sure method of maintaining purity in the seed supply is the propagation of pure strains, together with an annual renewal of the supply of pure seed.

The Propagation of Pure Strains.—The life of any pure variety of cotton may be prolonged indefinitely and its production in commercial quantities assured, if only the necessary and suitable precautions are taken.

Thanks to the knowledge that Mendel's Law has placed at our disposal, no great obstacle confronts those who set out to isolate a pure strain ; furthermore, the propagation of any particular strain from a few plants into commercial quantities need not be unduly tedious. Briefly, it consists in obtaining, by self-fertilisation exclusively, seeds from single plants, until plants are bred of which the offspring are all exactly alike in every measurable and visible feature. This is the work of the botanist, and to be successful it must be carried out in the laboratory garden under the supervision of experts and under special conditions which ensure that no cross-fertilisation can possibly occur.

The rapidity with which a new strain may be propagated is governed by the productivity of the plants rather than by the productivity of the soil. The problem in the laboratory

garden is, therefore, reduced to compelling a few plants to produce the maximum number of seeds, irrespective of the commercial aspect of yield per acre. Hence, wide spacing between the plants is resorted to, which, although it reduces the yield per acre, due to the waste of space, nevertheless increases the yield per plant. Experiments carried out by Dr. Balls at Giza, near Cairo in Egypt, have proved that whereas an average plant under field conditions of close spacing will give 300 seeds, producing 10 plants to every 100 seeds, a similar plant will produce 1000 seeds, giving 60 plants per 100 seeds, if the system of wide spacing is resorted to.

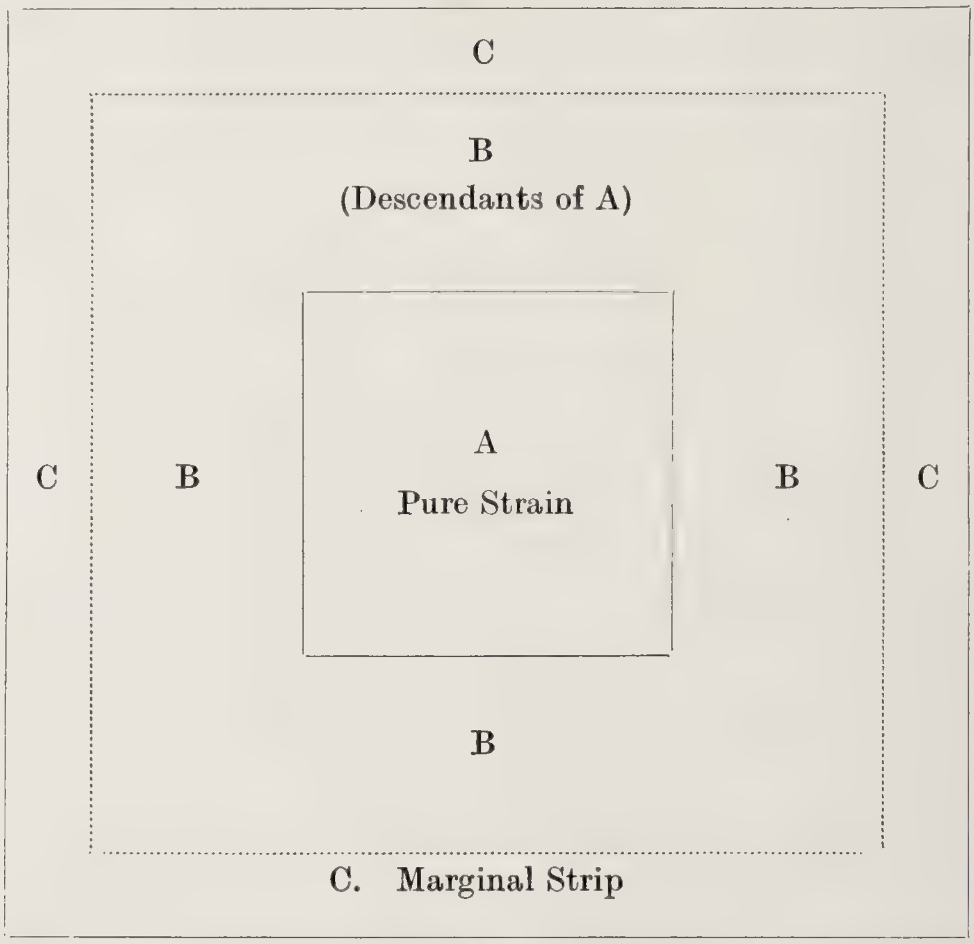
In publishing the above figures, Dr. Balls says: 'These figures are based on actual statistics of results over several years, and they show that a considerable change in velocity may be effected by wide planting, seed dressing, planting beans with the seed to break the soil, and so on. But this change is more important than appears at first sight, for if we continued these precautions for a second year, raising 600 wide-sown plants on about half an acre of land, we could get from their seed 360,000 plants in the next year, as against 900 had we pursued field sowing throughout, if we were prepared to sacrifice 100 acres to wide sowing in one year more. Beyond this point it is not practicable to sacrifice land to wide sowing, with a yield of two, instead of five, kantars to the acre [*i.e.* 200 instead of 500 lb. of lint], but you must note that we should start our next year with 8000 times, *i.e.* $(\frac{600}{30})^3$, more seed than we should have had by practising field sowing throughout the three years, and from these hundred sacrificed acres we should take 300 ardebs of seed (one ardeb equals 268 lb., *i.e.* a total of 80,400 lb.), which should sow a thousand acres of land in the fourth year from a single plant.' [1]

The method employed in Egypt for the propagation of pure strains was to grow individual plants under mosquito nets, or a number of plants in bee-proof cages, composed of wire gauze having 144 meshes to the square inch, through which even the ordinary house-fly was unable to penetrate, thereby ensuring that no fertilisation of the plants occurred from without the strain. Experience proved that both these methods had disadvantages; firstly, by reason of the expense incurred in providing the necessary mosquito nets and bee-proof cages; and secondly, it was found that even the very slight shading effect produced by the wire gauze resulted in

[1] Lecture on Seed Breeding, by W. L. Balls, M.A., Cairo, November, 1912.

the production of abnormal and straggly plants. The method now employed is to place small muslin bags, or bags composed of mosquito netting, over the flower bud, the mouth of the bag being tied to the stem of the bud. This effectively prevents bees or other insects reaching the flower, and does not affect the growth of the plants. As a further precaution during the period of growth, the plants must be rigidly inspected to ensure that no stray rogues or hybrids have been accidentally included ; should these appear they must be immediately weeded out.

In the following year, the seed obtained from these specially protected plants is transferred and sown in plots by



itself, and is again protected from cross-fertilisation in a similar manner, while during this year also the plants must be closely watched as a precaution against the possible inclusion of hybrids. It is not practicable to proceed beyond this point at the laboratory garden with wide-sown plants, and the seed must therefore be transferred to the seed-farms, where it is cultivated under normal field conditions.

The system employed on the seed-farms is to sow the pure laboratory seed in the centre of a field composed of its own descendants (*i.e.* descendants of an earlier generation of the

same strain), which, by forming a wide barrier all round the pure variety, reduce the possible risk of its contamination to the minimum : a bee or other foreign pollen-carrying agent visiting the field is almost certain first to alight on the flowers of the plants at the edges of the field, and thus rid itself of all the foreign pollen it may carry before it arrives at the pure plants situated in the centre.

As yet, there appears to be no precise information with regard to the depth to which cross-fertilisation may penetrate into such a field, but it seems reasonable to suppose that if we exclude a buffer, or marginal, strip ten yards in width all round the edge, the remainder of the field should be pure.

In the following season the seed resulting from A (the pure laboratory seed) is sown in the area B and therefore forms a cushion of pure (or almost pure) plants round the pure strain in its centre. The seed resulting from the plants in area B is distributed to cultivators of good repute, or else to all the farmers in one defined area, on the condition that the seed resulting from their crop shall be returned to the controlling or central seed-distributing agency for sending to cultivators situated in other areas, the seed resulting from the latter's crop being sent to the crushing mills, where the cotton seed is converted into oil, cotton meal and cattle cake.

Seed from the marginal strip C must be sent to the crushing mills, and on no account is it to be distributed by the seed-farm as sowing seed.

Isolation of the seed-farm by an area of grazing or bush land around it will naturally tend to minimise the risk of cross-fertilisation as long as the farm is confined to the production of one variety of cotton. In Australia, therefore, no difficulty should be experienced in the isolation of these seed-farms, which are so essential for the success of this new industry.

Testing.—It is not sufficient merely to produce pure strains, for little or nothing is gained if the variety produced is unsuited to the country, and it therefore remains to test the strain in various districts. A cotton admirably suited to central Queensland and giving big yields of excellent cotton in that locality may nevertheless, for example, prove an utter failure, or merely give poor returns, when grown in the Northern Rivers district of New South Wales.

In the testing of any pure strain it is necessary to grow it under normal field conditions in order to arrive at a true estimate of its commercial possibilities. These conditions

are obtained by selecting a piece of land typical of the district where the variety is to be introduced, and by planting this land with ordinary cotton, excepting certain ridges or observation rows which are sown with the pure strains to be tested. The ordinary cotton thus forms a sort of packing material around the observation rows, which are systematically scattered about the field, producing normal root, air and sun conditions which would be lacking if the variety were sown in a small plot by itself; while by systematically scattering these rows about the field fluctuations attributable to patchiness in the soil or subsoil are practically eliminated.

Data relating to the plants must be obtained, such as plotted plant curves, commencement of flowering, number and weight of bolls, yield, ginning out-turn, etc., so that at the end of the season precise information may be furnished from which to appraise the commercial value of the strain in that particular district. The tabulation and the procuring of these data are the work of the scientist, the absolute accuracy of whose results must be relied on.

One of the greatest advantages of a pure strain is its rigid precision. If placed in a new environment it will state its like or dislike for that environment for good and all in the first season. Neither coaxing nor persuading will induce it to acclimatise. Since we know how it should behave and what its capabilities in other districts amount to, we are at once able to state whether or not it is suited to the new district.

Renewal of Pure Seed.—To maintain a standard of purity and uniformity in the commercial lint, it is also necessary that there should be a continuous renewal of pure seed from within, for unless the supply of pure seed is perpetually renewed any impurity which enters into the strain will increase annually and cause rapid deterioration. This standard of purity may only be obtained through the agency of the laboratory gardens and their attendant seed-farms, together with the annual selection from plants in the field, cropped for renewal of seed. This procedure of producing pure seed afresh each year must in time wash all impurities out of the strain and into the crushing presses of the oil mills, where the doubtful seed is destroyed.

As long as this system of continuous renewal is employed it is impossible for serious deterioration to take place, and consequently a high standard of purity and lint uniformity can be relied on in the commercial crop. That it is possible

to put this method into execution with beneficial effects has been proved in Egypt, where, to a certain extent, State seed-farms have succeeded in preventing the rapid deterioration of Sakellaridis cotton : the only reason why they have not been completely successful is that the Egyptian seed-farms are not large enough to supply sufficient pure seed, as their entire output amounts to only one per cent. of the total crop of that country.

It is of course true that if impure seed were to be distributed by the seed-farms it would contaminate the output of the whole country ; but it may safely be said that the risk of this occurring is almost non-existent, for it would be well-nigh impossible for four generations of an impure strain to escape the expert supervision that is exercised over it during the two years' growth in the laboratory garden and two seasons' cultivation on the seed-farms.

Control of Seed Distribution.—This is the most vital factor, for on the exercise, or otherwise, of this control the whole issue depends. It has been shown how cross-fertilisation takes place, how mixture of seed may occur, and how the quality of a variety immediately deteriorates once these evils have set in. It has been demonstrated that to a certain extent these evils may be remedied on the institution of seed-farms, but these are only remedies and antidotes which will tend to lessen the ill-effects—they are not preventives.

Briefly, yet with the most exact definition of every word, the prevention, the cure, lies in a rigid, an impartial, yet an absolute control over the distribution of *all* sowing seed by one organisation, which must have complete power in all matters appertaining thereto.

Furthermore, the whole problem must be looked at from a broad-minded view-point, placing the good of the community, and of the country as a whole, before that of the individual.

Experience in other cotton-growing countries has conclusively proved that certain soils and climates are particularly adapted to specific varieties of cotton, and it is reasonable to suppose that this will also prove to be the case in Australia. Before one can speak authoritatively on this point the necessary information must first be obtained, and this can only be acquired by experience and experiments in various localities. Now, if these experiments are to be of any real value they must be controlled by practical scientists accustomed to this type of field work, who, even though they are not actually growing

the cotton themselves, can instruct the selected growers how to obtain the necessary data relating to the experiments, and can personally supervise and accurately check the results. Until this information is obtained it would be very unwise to attempt any large-scale production of various varieties in districts which may prove to be utterly unsuited to them, and, in the meantime, undoubtedly the wisest course would be to concentrate on the production of only one variety of pure good quality cotton throughout the entire country. The whole aspect of the case would change, however, when once different pure strains had been scientifically and accurately tested throughout various localities in Australia, for then the organisation controlling the distribution of seed would have definite facts and figures to work on, which would place it in a position authoritatively to state what varieties should be grown in prescribed areas in order that the best and most profitable results should be obtained, together with the correct steps the growers should take in order to get the maximum returns from their crops.

As it has been suggested that this Seed-distributing Organisation should be vested with complete power, the next step which they should take would be to divide the country up into clearly defined sections or subdivisions, each of which should have an area sufficiently large to produce enough cotton to keep at least one ginning factory employed. To each of these defined sections only one variety of pure seed would be allotted—the variety of seed which experience, backed by accurate data, had proved to be most suited to it. This method would ensure the complete isolation of each section, and guard against the possibility of natural crossing in the field or mixture of seed at the ginning factories. The introduction, or growing, of varieties other than that which is recommended by the Seed-distributing Organisation for that section would have to be prohibited, and those who attempted to introduce any strange or foreign variety therein would be penalised: for by so doing they would endanger the purity, and consequently the value, of their neighbours' crops in that section.

An arbitrary control such as the foregoing would greatly simplify the propagation and maintenance of a pure seed supply, resulting in the best and most profitable returns being obtained from each district, and consequently from the country as a whole. As the product of a pure strain does not vary,

the cotton produced would have greater value in the markets of the world, for spinners would more readily purchase it when they knew that a further supply of identical cotton would be available during the following season.

Another very important point, especially when looked at from the view-point of American experience with the boll weevil, and one which may play a great part in the future of cotton in Australia, is the facility which a complete control over the seed supply also gives to the controlling of any pests that may arise. In almost every case the spread of cotton pests or diseases is through the medium of the seeds themselves. The grubs of the boll weevil, the pink worm and the boll worm —the three worst pests which attack cotton—live in the cotton seeds during the later stages of their existence, as caterpillars, and until such time as they crawl into cracks in the ground and turn to chrysalides. If the distribution of sowing seed were controlled it would tend to minimise the spread, or at all events the rapid spread, of disease from one district to another. It would also render it humanly possible to localise the malady and confine it to the attacked area, thereby simplifying the task of combating it. All seed produced in the affected area would be dispatched to the nearest crushing mill and destroyed. Fresh, clean, pure sowing seed could be imported from non-affected areas to take the place of the seed destroyed and, even should these measures not succeed in the complete eradication of the disease, they would go far towards limiting its ill-effects and be a safeguard to the country in general.

The fact has not been overlooked that this suggested rigid control of seed distribution may in some cases prove to be a hardship and a handicap to a minority of cultivators. In sections where the bulk of the country is admirably suited to the allotted variety there may yet be small areas of soil where a variety, other than that allotted, might give better results ; and in these cases control of the seed supply is bound to cause some dissatisfaction ; yet it would be grossly unfair to the majority of the cultivators if a few individuals were allowed to jeopardise the welfare of the bulk of the community.

The question naturally arises as to what body or organisation should be entrusted with this complete control in the matter of seed distribution. There are those who will doubtless immediately reply—the Government ; but there are others who may prefer to see this task entrusted to those who are not influenced by politics and general elections. This is a point

for Australians to settle themselves, but on first principles it would seem preferable that this important work should be entrusted to those who are not directly concerned in politics, to some outside organisation which is connected with the cotton industry and has at heart the welfare of this invaluable product ; but, if so, it is necessary that they should be subject to Government supervision, so that irresponsible monopoly should be avoided. The combination of these two forces, business efficiency tempered by Government control, would seem to be ideal for the good of the country. If the majority of those concerned in the cultivation of cotton were not satisfied with the working of this arrangement they would still have it within their power to alter matters at the next general election, but it must be remembered that, once complete power is given to any Government, it is almost impossible to wrest this control from them.

The Australian cotton industry is as yet in its infancy ; it has not assumed huge proportions, even though it has attracted much attention, and consequently the difficulties of controlling the seed supply at the present moment are infinitesimal compared with what they may be in a few years. In order to foster this new industry the Government has had the foresight to guarantee a minimum price to growers for seed cotton, which guaranteed price extends over a period of years, and accordingly it more or less has the control of the industry in its hands. The exercise of control in the matter of seed supply should therefore present no difficulty that may not at this juncture be surmounted.

The greatest efficiency and the highest financial returns may only be procured by control of the seed, for by this means alone one can strike direct at the root of the evil.

CHAPTER X

THE CULTIVATION OF THE CROP

Fallowing—Planting—Rate of planting—Spacing between rows—When to thin—How to thin—Spacing between plants in rows—Cultivation during growth—Hilling cotton—When to pick—How to pick—Uprooting of old cotton plants.

Broadly speaking, the methods employed in the cultivation of cotton in Australia are very similar to those of the United States of America as regards sowing, spacing and the cultivation of the land during the growth period. As the bulk of the rural population of the Australian cotton belt have in the past been mainly engaged in sheep breeding or pastoral pursuits, and as most of them have had scant experience of tilling the soil or growing cotton, it is only natural that their general methods of farming should be neither as thorough nor as efficient as those of the cotton farmers in America, who have had a century's experience in the growing of this crop.

Fallowing.—The most important point in relation to cotton cultivation in Australia is the necessity for fallowing, and the need of thoroughly preparing the soil previous to planting.

Farmers in the wheat belts of New South Wales, Victoria and South Australia have learnt by practical experience the advantages and the necessity of allowing their land to lie fallow for either one or two seasons before planting it with wheat; and the maximum field results will not be obtained from cotton until such time as cotton growers employ similar methods. In Queensland especially, too much reliance is placed on the monsoons, and there are many who do not as yet appear to have fully realised the advantages that are to be gained by fallowing, or to what a great extent it acts as an insurance against crop failure.

In any district where the success or failure of a crop depends entirely on natural rainfall it is essential that the methods of cultivation be so arranged as to guard against the risk of

drought or years of deficient rainfall. Fallowing is of as great importance and urgency to the cotton farmer as it is to the grower of wheat. In fact, one is justified in going even further and in saying that if fallowing is practised with cotton, then this crop, by reason of its deep-seated root system, may be counted upon to give a payable yield in dry seasons when all other crops may be failures. The practice of fallowing is as old as the Roman period, and was first mentioned as being used in Australia in 1803.

Fallowing may, perhaps, best be defined as the process of ploughing the land and then allowing it to remain in an uncropped or fallow state for a period of time that varies to suit local climatic and soil conditions.

If fallowing is intelligently carried out, three great advantages are obtained, namely:

(i) *Conservation of moisture.*—Any rain that the land receives is retained and conserved in the soil.

(ii) *Increase of Plant Food.*—The store of plant food in the ground is increased through the agency of bacteria.

(iii) *Destruction of Weeds.*—The weeds are destroyed before they reach seeding stage, and the humus content of the soil is increased by the harrowing in of the weeds, which act as a green manure.

Moisture Conservation.—Land that is being put under fallow should first be ploughed and then cross-ploughed to a depth of from six to eight inches. Immediately afterwards sufficient harrowing should be given to break the surface up into a fine tilth, in order to retain whatever moisture there may be in the soil at the time of ploughing. The ground is now in a position to benefit to the maximum extent from any rain that it receives, as the water will readily sink into the soft receptive soil instead of running off the surface, as happens on hard unploughed land. The next step is to retain this moisture in the soil. Rain has the effect of closely compacting the soil grains or particles, and the surface of the ground when it dries will in nearly all cases form a hard crust. Capillary attraction is thereby established between the particles, and under the influence of the sun the moisture is sucked up to the surface from the lower soils. Under such conditions evaporation becomes constant and is very great during the heat of the day; consequently the land will rapidly give up most of the moisture it received, if allowed to remain

in this state. The surface crust must therefore be broken up into a fine mulch, which by again separating the soil grains from one another retards capillary attraction, checks evaporation and prevents the moisture from escaping from the land : only the surface soil becomes dry and powdery, whilst the lower layers remain moist.

A variety of implements may be used to suit local conditions, such as ordinary harrows, spring-tooth harrows, disc harrows, cultivators and scarifiers. The one most commonly employed is a disc harrow, as, by setting the discs at various angles with the line of draft, the soil is turned over as well as pulverised. The land should be harrowed after every rainstorm or heavy shower, so as to ensure that the stores of moisture below the surface and in the subsoil are increased instead of exhausted. The frequency of the harrowings has to be determined by local conditions ; but a safe rule to adopt is never to permit the surface soils to become hard or caked. This enables a large quantity of the rain that falls to be stored in the ground to uncertain depths—sometimes as much as eight feet—and renders it possible to conserve such moisture for periods extending over one year and so to raise one crop.

The conservation of moisture in the land is the paramount object of fallowing, but there are other important aspects, such as the weathering and the sweetening of the soil and the releasing of plant food.

Increase in Plant Food.—Soils contain certain chemical constituents that are useless as plant food when in an insoluble state. The ground also contains soil-bacteria or micro-organisms that are present to a small degree when the earth is dry and infinitely more numerous when it is moist.

The conservation of moisture has a two-fold effect : firstly, that of dissolving certain of the chemical ingredients, and secondly, of increasing the number of bacteria. These bacteria possess the beneficial function of converting plant food from an insoluble condition into one in which it readily dissolves in the presence of water. It is now definitely known that changes so created—termed nitrification—are essential to plant growth.

Each crop removes quantities of these nourishing elements from the soil ; and, were it not for this wonderful provision of nature, whereby such elements are restored through nitrification, or the conversion of insoluble nitrites into soluble nitrates, the land would rapidly become impoverished. The period of rest covered by fallowing enables soil-bacteria to

release this plant food, and to restore fertility to the soil before the next crop is planted.

Destruction of Weeds.—After the initial ploughing, fallows must be kept clean in order to destroy all growths of weeds. On good soils and under the stimulating influence of sunlight fallowed land will rapidly become infested with weeds. These must be destroyed in their earliest stages and before they have a chance to seed, either by cultivation or by the use of sheep or cattle. Where sheep or lambs are kept on a farm they prove an economical advantage, as they can be fed on fallow. All young growth of wild oats, weeds and thistles is eaten off close to the ground. Labour in cultivation is also saved, as the sheep break up soil surfaces, compact subsoils with their small feet and enrich the land with their excreta.

If weeds are allowed to grow, they necessarily utilise and exhaust both the moisture and the soluble plant food in the soil and defeat the object of fallowing.

'Cultivation' means the repeated *shallow* stirring of the top soil, so as to maintain a fine mulch on the surface and destroy weeds. Deep cultivation or ploughing of fallowed land is very detrimental, as it disturbs the seed bed, creates a loss of moisture by exposing damp soil to the air, and destroys bacteria, which perish immediately they are subjected to sunlight.

The fallowing period may vary with different districts, but in all cases it should be sufficiently lengthy to allow ample time for all stubbles and organic matter, ploughed under in the first instance, to decompose and form humus. As the climate of the Australian cotton belt is divided into dry and wet seasons, it is in general only possible to plough after the monsoonal rains have commenced and have softened the surface of the ground. It therefore follows that the sowing of cotton must either occur almost directly after ploughing, when the ground is raw and newly turned, or else the land must lie fallow until the following year.

If, in normal seasons, planting occurs immediately after ploughing, the land will not have received sufficient rain to soften the subsoil thoroughly. Consequently the tap-root, instead of penetrating the lower layers, will be turned in a horizontal direction when it strikes the hard, dry soil untouched by the plough, and will be forced to develop into a lateral root, which is most undesirable.

There can be no question concerning the necessity or the

advisability of fallowing cotton lands in Australia, nor is there any obstacle to prevent this practice being put into execution. Cotton is destined to be cultivated in small individual areas which in all probability will not exceed ten acres per settler. The fallowing of an area similar to that which is actually under crop is therefore well within the scope of the average grower. Neither the labour nor the expense of fallowing ten acres is great, whilst the advantages are many. The fertility of the soil is increased, stable and reliable returns are ensured from the crop ultimately planted, and the risk of failure due to dry seasons is minimised. The additional expense entailed for labour is more than compensated for by the above, and by the decreased need for weeding when cotton is sown on clean fallowed land. A firm, moist seed bed is also obtained: this ensures good germination, lessens the need for resowing, and gives the crop every chance of firmly establishing itself under excellent conditions at the outset.

Further, it is inadvisable to grow cotton on the same land year after year, for not only does this impoverish the soil, but it also increases the risk and the extent of damage caused by insect pests. The practice of fallowing will guard against these evils. Most pests, their larvæ or their chrysalides, take refuge during the winter months in the ground near the old cotton plants. If cotton is grown on fresh land during the following season, many of these insects will die, as when they come out of the ground in the spring there is no young cotton in their immediate vicinity for them to feed upon.

Planting.—Upland cotton seed as it comes from the gin is covered with a short fuzz which adheres tightly to the seed (this fuzz is known as 'Linters' when removed from the seed). The presence of this fuzz makes the seeds cling together and prevents them from running freely. In America there are special cotton planters that effectively sow the seeds when in this state; but practically no such machines are as yet in use in Australia. This is largely due to the protective tariff and the high duty on imported machinery. Extempore methods of sowing have therefore had to be devised. The cotton seed is dipped in a thin solution of clay, mud, or flour paste, and is then rolled so as to ensure an even distribution of the paste coating. The rolling may be accomplished by putting the treated seed in a sack and rolling it from one end of the sack to the other until smooth. The seed is then placed in the sun and thoroughly dried. This process cakes the fuzz

to the seeds, making it possible for them to be planted with an ordinary maize planter. The knocker and brush are removed from the planter and a disc plate, provided with eight holes, is used.

Sowing should occur after a good fall of rain and whilst the ground is still moist. Even distribution of the seed and uniform depth of planting are most desirable. The seeds should be sown in continuous rows and lightly covered with from one and a half to two inches of fine soil.

Germination may be hastened by soaking the seed in water overnight, or in warm water for some few hours previous to planting. The soaking of seed is impracticable if it has to be sown with a maize planter—as the seed will not run—and may only be employed when a special cotton planter is available, or when the seed is sown by hand. It is not wise to plant soaked seed in dry ground, as the seedlings will sprout and are then very liable to die before making contact with the moist earth below the surface layer of dry soil.

The securing of even germination and a good stand are most important factors, as without a good stand the grower is prevented from obtaining the maximum yields that his soils are capable of producing. A heavy sowing in the first instance, in a properly prepared seed bed, is the cheapest and the surest way to achieve this result. An uneven germination is also a handicap at thinning time, as, when plants are of different heights and stages of development, they will not all be thinned at the proper stage.

Where local conditions and the slope of the land will permit all rows should run in a direction due east and west. This is the universal practice in Egypt, and guarantees that the plants will receive the greatest possible amount of sunshine and warmth from the sun's rays. If the rows run north and south the plants have a shading effect on one another.

Rate of Planting.—In the United States, after years of experience and experimenting, it is the general custom to plant at the rate of 20 lb. of cotton seed to the acre. In Australia the rate is at present 15 lb. to the acre. This might possibly be increased with advantage, as thin sowing is foolish economy.

Spacing between Rows.—The general practice in Australia is to space the rows from about four feet to five feet apart. No definite decision can be given on this point, as there is not as yet sufficient evidence. Different soils and climates need

A Load of Cotton Seed for Distribution amongst Cotton Growers in Queensland. Season 1923–24.

different spacings both between the rows and between the plants in the rows: the correct distance can only be determined by experience, and growers are strongly urged to experiment for themselves. It does not seem advisable to space the rows less than four feet apart, as it may be necessary to cultivate between them late in the season, and sufficient space must be left to permit of a horse being worked in the cotton without doing severe damage to the branches.

When to Thin.—Lack of Australian field experience prohibits the making of any precise statement as to what length of time should elapse between the sowing and the thinning of the crop. Neither is it possible to say definitely how tall the plants should be when thinning occurs. Until reliable data have been accumulated it is unwise to make any recommendation. Soil, climate and rainfall have a most important bearing on this subject, and growers are advised to experiment for themselves.

One is merely justified in proffering tentative suggestions based on a study of normal climatic conditions. Thus, in the North-Western Districts of New South Wales (*vide* Diagram No. 1, Chapter V), where October 31 is indicated as the optimum planting date, and where both temperature and rainfall are less than in Queensland, it would seem advisable to thin the rows when the plants are about six inches high. Cotton develops more slowly and more normally in regions of moderate precipitation and temperature, and New South Wales cotton should be well established by the time that the plants have attained a height of about six inches. The average rainfall appears to be sufficient to permit of normal development up to this point, but if thinning is further delayed in the inland areas of that State, then growth is almost certain to be checked, as closely sown and unthinned plants would not be able to derive sufficient moisture from the soil.

In Southern Queensland, where the temperature is higher, the rainfall is greater and the optimum sowing date for American Upland varieties is one month later—namely, November 30 (*vide* Diagram No. 6, Chapter VI)—different conditions prevail. The plants may be expected to have a tendency towards rapid, rank and excessive vegetative growth—cotton sown in November/December during the season 1922–23 behaved in this manner—and it is therefore suggested that thinning should be delayed until the plants are about ten inches tall. This should have the effect of restricting

growth and of preventing the formation of excessive vegetative branches. The same should apply to the Northern Coastal Districts of New South Wales. In the Coastal Districts of Queensland, where the rainfall is even greater, it may be necessary still further to delay thinning, so as to starve the plants and check rank growth in the early stages.

How to Thin.—Many growers have been of the opinion that the young plants should be pulled up by hand. Not only is this method expensive, tedious and back-breaking, but it is also detrimental to those plants that are left standing. When plants are hand-pulled, the ground around the remaining plants is loosened and a considerable amount of moisture is lost through evaporation from the cracks left by the uprooted seedlings.

The easiest and most efficient method is to use a well-balanced sharp hoe about seven inches in width. By this means two operations are performed at once, as the young plants that are not required are hoed out without disturbing the soil around the roots of the remaining plants, and the weeds or grass seedlings are also removed.

The edge of the hoe should be kept sharp, as this ensures a clean cutting-off of the plants and also reduces the amount of effort required to accomplish the work. Care must be taken to leave healthy normal plants whenever possible. Forked plants or those with a damaged leader should be hoed out, as such plants have a tendency to develop bushy or stunted growth.

Plants that are being thinned-out should be chopped off just below the surface of the ground: in this way they will effectively be killed. One man should be able to thin-out an acre of cotton a day.

Spacing between Plants in Rows.—There are no reliable data for either Queensland or New South Wales regarding the proper spacing to be adopted between plants in the rows. Climate, rainfall and soil are all important factors in this respect, and the most suitable spacing for the soils of the various rainfall districts can only be ascertained by experiments conducted over a number of years. At present the spacing varies from about six inches to about fifteen inches, and the average distance is in the neighbourhood of eight or ten inches.

It is recommended that not more than one plant be left to the space. This guarantees that each individual plant shall receive the maximum nourishment and moisture from

the surrounding soil. If two or more plants are left to the space, the competition for plant food and the lack of moisture in seasons of deficient rainfall will check their development and will have a detrimental effect on the yield and the quality of the lint. The same is applicable to the growing of three or four plants to a hill.

Cultivation during Growth.—Surveys made by the United States Department of Agriculture have shown that six cultivations after the crop is planted is the average number for whole districts in that country. Four cultivations may be taken as the average number at present given in Australia, and it is considered that this number might be increased with advantage. Undoubtedly, frequent cultivations are necessary, particularly in the early stages, in order to keep down weeds. Even if the crop is free from the latter, cultivation is still essential to conserve moisture, and as soon as the ground dries after rain it should be cultivated so as to break up the surface crust and convert it into a fine mulch that will prevent evaporation.

The first cultivation should be made as soon as the young cotton appears above the ground. Another cultivation should be given after thinning ; and then as necessary.

Good cultivation and attention on the part of the grower not only increase the ultimate yield but also improve the quality of the cotton.

Hilling Cotton.—As the plants increase in size the loose dirt should be gradually worked towards the rows. This practice establishes a mulch around the plants that not only prevents evaporation from the ground between them, but also smothers weeds in the rows that cannot otherwise be reached by horse cultivation, or easily checked unless hand hoeing is resorted to.

At the ' laying by ' of the crop, *i.e.* the final cultivation before the plants become too large, it is advisable to hill-up the plants to a good extent. This serves as a brace and assists the plants in resisting heavy winds.

This ' laying by ' is usually accomplished with disc cultivators, but care must be taken that the machines do not cut deeply enough to sever the surface roots.

When to Pick.—Picking should commence when there is a good flush of cotton visible—that is, when about one-third of the bolls are ripe. It is often difficult to judge by merely looking at a field if there is much cotton ready for picking, as frequently a quantity of ripe cotton is hidden by the leaves.

Felling Scrub.

The best way to decide this point is for the grower to count the number of bolls on several typical plants in various parts of the field. If it is found that approximately from one-quarter to one-third of the bolls are fully open, then the first picking should commence.

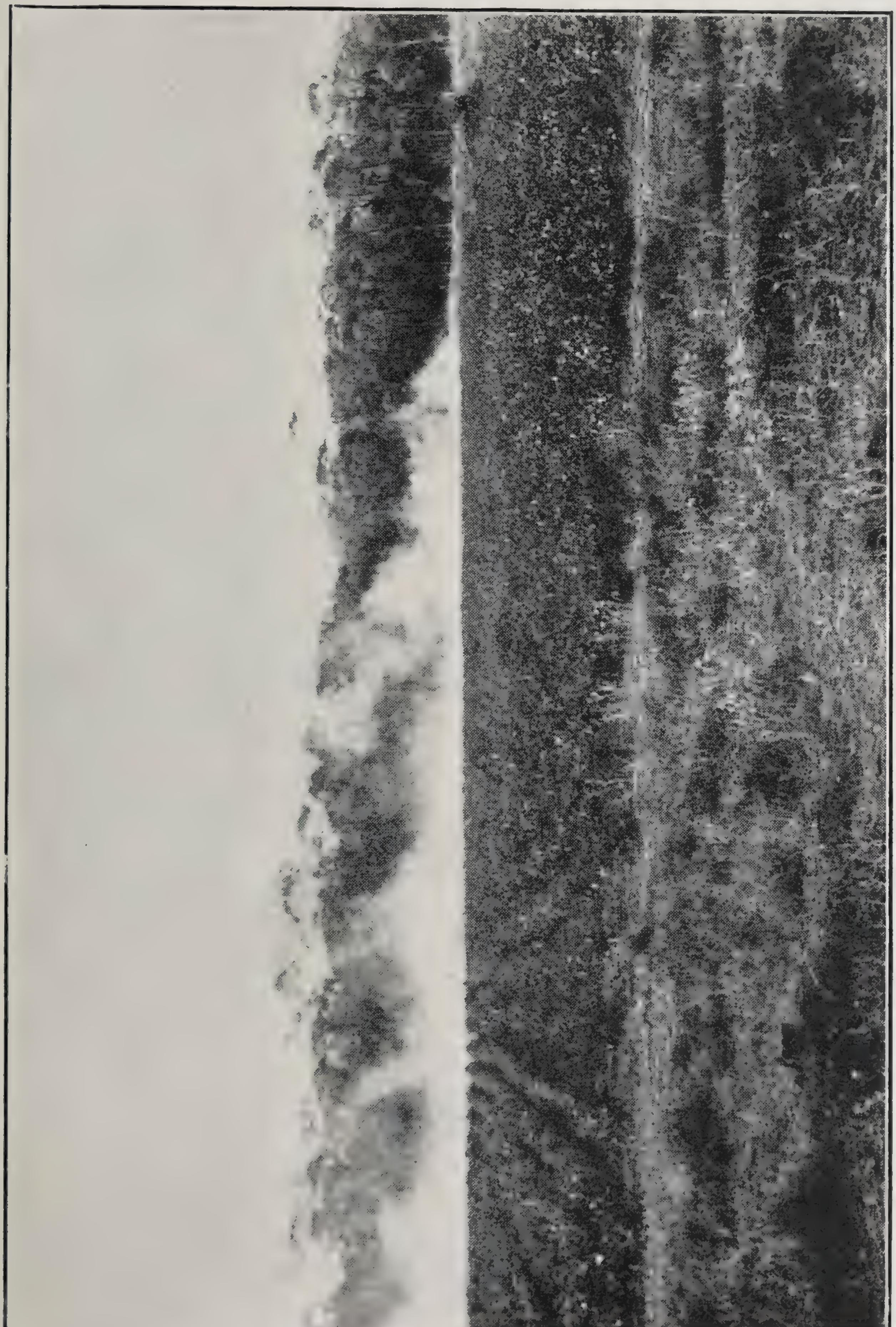
It is essential that only mature seed cotton from fully opened bolls should be picked : cotton in half-opened bolls is not properly ripe and should be left on the plants for gathering at the second picking. Not only does the picker lose time by endeavouring to prise cotton out of half-open bolls, but such cotton is immature and has a lesser value.

Most Australian crops will give three pickings. The second picking should start when about half the remaining bolls are mature and fully open. The third should take place when the bulk of the remaining bolls are ripe. After this picking the plants should not hold sufficient cotton to justify further time or expense being devoted to them.

The foregoing recommendations hold good where the grower has to employ labour for picking. In cases where he has himself to pick ten acres of cotton without employing outside help, the first picking should commence when about one-quarter of the bolls are ripe, and the field be systematically picked from end to end. In such cases it will usually be found that by the time the field has been once picked over the plants at the far end, from which the cotton was first gathered, are ready for their second picking. Picking will, therefore, be almost continuous.

As gathering the crop occurs in the cool autumn season, it is no hardship for a grower's family to assist him in it. Women, and children of twelve or fourteen years of age or upwards, can frequently pick more cotton than men, as they are in most cases more nimble with their fingers.

How to Pick.—It is most important that the pickers be provided with proper sacks for holding the cotton as it is picked. The cotton pickers of the United States mostly use heavy duck sacks, some thirty inches wide and seven or eight feet long. These sacks are either tied round the waist or suspended by a strap over the right shoulder and across the breast. The mouth of the sack is level with the picker's left hip, and the length of the sack allows the weight of the cotton to rest on the ground behind him without pulling on his hips. This allows freedom of movement to the body in bending over the plants, and to the hands in picking the cotton.



Smoking out Beetles.

The amount of cotton secured daily is greatly increased if the crop is systematically picked. Time is lost if the picker endeavours to gather the cotton from the plants on either side, or if an attempt is made to reach over, or through, the bushes. The most efficient method is to pick one side of a row at a time—the left-hand side is usually easiest—and, when the end of the row is reached, for the picker to turn round and retrace his steps, picking the cotton from what was the right-hand side of the row on the way up.

Care must be taken to pick the cotton clean, as clean-picked cotton has a much greater value than that which contains particles of leaf, husk, dirt, foreign matter, or immature cotton. A small amount of dirty cotton if mixed with clean lowers the value of the clean cotton out of all proportion to the quantity of dirty cotton added.

Wet cotton should not be picked. There is no great objection to picking cotton while still slightly damp from the morning dew, *provided* that it is immediately spread out on clean sacking or a wagon sheet and is thoroughly dried in the sun before being packed into sacks or bales. Damp cotton quickly heats and becomes discoloured, thereby decreasing in value and also adding to the difficulty of ginning.

Picking should not be unduly delayed, as, although cotton may as a rule remain on the bush for about a fortnight or so without being damaged, long exposure to the sunlight robs it of some of its bloom and character. There is also the danger that wind may cause leaf or dirt to become mixed with the fibre, or that unseasonable rainstorms may stain the cotton and cause loss through part of the crop being beaten to the ground.

Each picking—and the various grades of seed cotton—should always be kept separate. They should never be mixed together, and should be forwarded to the ginning factory in separate bales or wool sacks.

Uprooting of Old Plants.—Laws recently passed by the Queensland and the New South Wales Governments have made it compulsory for all growers in Australia to destroy the plants at the end of each season. Where the grower has prepared no other land, and is therefore forced again to plant the field with cotton in the following season, the old plants should be ploughed out, raked together and burnt. This assists in destroying any bacterial or fungoid diseases, and any insect pests that may be in the unopened top crop of

bolls, thereby leaving a clean field for the ensuing crop. It is not advisable to plough the old bushes into the ground, as they will not have sufficient time to decompose before the next crop is sown, and difficulty will be experienced in obtaining a firm, moist seed bed.

In cases where the grower intends to let the old field lie fallow throughout the following summer, the old bushes should be ploughed under. In the cotton belt of America, where the winter rains are heavy enough to pack the soil firmly and rot the old bushes, the plants are invariably ploughed-in. This enriches the soil with humus when the old stalks decay, and might be followed with advantage in Australia ; but only in instances where fallowing is practised.

CHAPTER XI

CONCLUSION

Need for scientific research—Picking limitations—Big-bolled types necessary—Planting periods—Available cotton lands—Immigration—Future prospects.

Need for Scientific Research.—Probably the most urgent need at the present moment is for thorough and scientific research into the habits of the cotton plant in Australia. Until accurate data are obtained relating to the behaviour of the plant under the varying climates of the different rainfall districts it is quite impossible to put forward definite recommendations concerning its cultivation.

Fully qualified plant breeders, experienced in practical field work, are required, as the most suitable varieties of cotton for each locality have yet to be ascertained. A staff of entomologists who have specialised on cotton pests and diseases are also an urgent necessity. As yet cotton in Australia is particularly free from disease, but it does not follow that this state of affairs will last indefinitely. The experience of nearly all cotton-growing countries is that little damage is caused by pests or diseases in the first few years. The danger is that after two or three good seasons, when the farmer's faith in the crop is thoroughly established, some insect pest or disease that has up till then lain dormant, or been gradually developing unnoticed, may suddenly cause grave havoc and involve the country in heavy loss. Constant watch on the part of entomologists would minimise this possibility.

Where cotton is grown under natural rainfall it takes longer to acquire accurate data relating to its growth than is the case where it is cultivated under irrigation. Variations between the rainfalls of one year and another upset calculations, and render it more difficult to arrive at conclusions concerning the most advantageous methods of cultivation and spacing. The local Governments are taking steps to acquire this information, but

they have not the same store of knowledge or information at their disposal as has an organisation like the Empire Cotton Growing Corporation, whose activities are world-wide. This Corporation has recently dispatched one cotton entomologist to Australia, and it is greatly to be hoped that this step may be followed up by the establishment of a fully equipped Research Institute in that country.

Picking Limitations.—Owing to the high standard of living and the cost of labour in Australia cotton cultivation will almost certainly be restricted to small individual areas, averaging about 10 acres per grower. The cultivator and his family can easily handle this area without engaging labour for picking. The size of the crop must, therefore, be limited, in the first place, by the rural population and the number of growers, and in the second, by the amount of cotton that can be *picked.* One grower can easily plant and bring to maturity 30 acres of cotton, but he can only pick 10 acres unaided. The problem that confronts the plant breeder therefore primarily resolves itself into breeding types of cotton that can be picked easily and rapidly.

Big-Bolled Types Necessary.—Small-bolled Egyptian or Sea Island varieties of cotton will almost certainly prove uneconomic for Australia. The bolls of such types are neither as large as those of American Upland varieties, nor do they open as fully. Thus, not only is more time required for picking, thereby restricting the acreage that a grower can cope with, but it is also more difficult to pick clean.

The ideal cotton for Australian conditions in general would seem to be some variety of long-stapled American Upland, such as Durango or Webber 49. The fibre of such types is nearly as valuable as that of Egyptian varieties, but the Upland bolls are much larger and easier to pick.

The task facing the plant breeder is the propagation of *large-bolled* types of long-stapled American Upland varieties. His object should be to produce plants giving a good quality fibre of about one and a quarter inch, or over, in length, yet with bolls, if possible, as big as oranges. The husks or segments of these bolls when ripe should peel back till almost at right angles to the stem. This would facilitate the picking of the crop, and, coupled with an increase in the size of the boll, would permit of a greater weight of cotton being gathered per day. This would augment the production per head and would very materially help to increase the volume of the crop.

It is quite possible that any marked increase in the size of the bolls may cause a decrease in the number of bolls per plant. Even should this prove to be the case, large-bolled varieties will still prove to be a very great advantage provided that the actual yield of cotton per plant is not thereby very appreciably diminished.

Planting Periods.—It would appear that during past seasons Upland cotton has in very many instances been planted *too early* in the spring, *i.e.* during September and October ; and much of the first picking has consequently been subjected to the rains of the late summer and early autumn months of February and March.

This early sowing has been advocated in order to guard against rank growth, as the plants develop more normally whilst the temperature and rainfall are comparatively low than they do later in the spring after the monsoons have properly commenced. But, although normal development is most desirable, the quality of the fibre must not be sacrificed, and early spring planting has two grave disadvantages. The early spring rains in Queensland are not dependable, and are of the thunderstorm type ; consequently where early sowing has been practised there have been numerous cases where complete resowing has been necessary. In many instances districts have received sufficient rain to secure germination and to give a good stand, but often enough these early-sown plants have wilted and died, as they have received little or no rain from the time of planting until about the end of November, when the monsoon almost invariably commences. Further, if early planting is employed, the crop ripens before the wet season is over, and much of the cotton is liable to be stained or tinged.

Cotton is grown for its fibre. This fibre must be unstained and of good quality if it is to realise a high price. It is accordingly recommended that planting should not occur much before or after the dates indicated in Chapters V and VI, as these suggested dates should ensure the crop ripening in the dry period of the year.

Sight has not been lost of the fact that, in Queensland especially, the plants will tend towards rank growth. This would appear to be a problem that must be squarely faced, and efforts should be made, either by means of close spacing or the propagation of special varieties, to check the tendency.

From the view-point of the industry in general, plants of

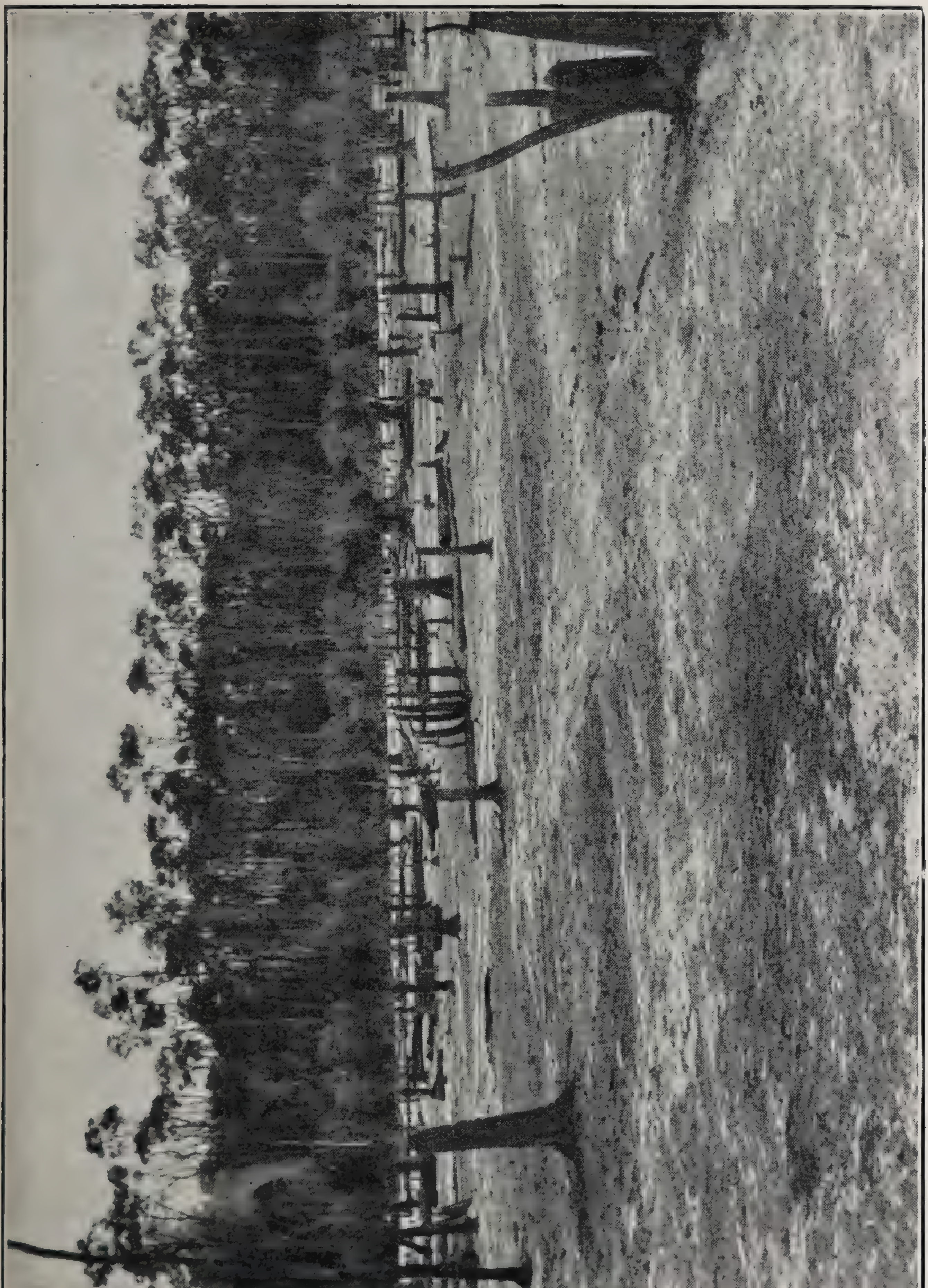
View No. 1.—Partially felled Scrub, previous to being Burnt.

a somewhat rank growth, but which give a clean, good quality fibre, free from stain or water damage, are much preferable to those of normal development whose product has been damaged by rain, through early sowing and early ripening.

Available Cotton Lands.—There are millions of acres of land in Queensland with a suitable climate and rainfall that are admirably adapted for the growing of cotton. Some of this land is held by private individuals, but there are still vast areas of Crown Lands. These Crown Lands are gradually being opened up for settlement. To quote one instance: at the present moment some 3,000,000 acres of virgin country, in the Burnett and Calide valleys of Southern Queensland, are being thrown open by the Queensland Government for selection. This tract of country is approximately situated between Wowan and Gayndah (*vide* diagrams Nos. 6 and 8 for climate and rainfall). Some of it has already been taken up, but there yet remain large areas available. There are many other regions, equally suitable, where land may be obtained under similar terms from the Government. These terms are very briefly as follows:—

The Crown leases land under what is known as 'perpetual lease.' The offset, or valuation, price of the land is fixed: this naturally varies with different districts, but is roughly in the neighbourhood of from £2 10*s.* to £3 10*s.* per acre. Rent is charged at the rate of $1\frac{1}{2}$ per cent. of the offset price, during the period of the first fifteen years; in other words, the rent is roughly equivalent to 10*d.* per acre per annum. During the first two years following selection, no rent need be paid to the Government, and this gives the settler a fair chance to get established. At the end of the first period of fifteen years the land is revalued, and rent charged accordingly. Full particulars of land, and land settlement schemes, may be obtained from the Queensland Government Office in London, from Australia House, Strand, London, or else from the Lands Departments of the various States in Australia. Some of the land is cleared and some covered with bush, but when the farms are laid out by the Governments in the first instance, every effort is made to give each farm a portion of cleared and a portion of uncleared land.

Immigration.—No great capital is necessary for the cultivation of cotton, as the main implements required are a plough and a cultivator. Within six months of sowing the crop may be turned into cash. Thus, by reason of its quick return and



View No. 2.—The same Scrub Land after the 'Burn' and ready to be Planted with Cotton.

the small outlay required, cotton holds out great prospects for the new settler of small means.

Immigrants who intend to take up cotton growing would be well advised not to start out on their own account immediately they arrive in the country. Much labour, expense, heart-burn and disappointment may be saved them if they first gain a general knowledge of local conditions and methods of cultivation. Such knowledge may be easily acquired by spending one season as a paid farm hand, or by working on the land on the share-farming system. Share-farming has much to recommend it: the owner provides the land and the necessary implements, whilst the settler provides the labour. The resulting crop is divided between them, usually on a half-and-half basis. When once the settler has obtained an elementary knowledge and has saved up a certain amount of cash, he is in a far better position to start operations on his own with success. Further, if he has kept his eyes open and has made good use of his spare time, he will know the most suitable class of land to take up.

Scrub lands are almost always rich lands, with a deep retentive soil, and when cleared are in general eminently suited to cotton. As a certain amount of labour is necessary to get rid of the scrub, such lands may in most cases be obtained cheap. The Queensland scrub consists of smallish soft-wood trees, about as thick in diameter as a man's thigh, and may be very easily cleared. The usual practice is to fell all trees and any of the large undergrowth in one direction. This distributes the felled scrub evenly over the ground, and does much to ensure the obtaining of a satisfactory 'burn.' The felled scrub is allowed to remain on the ground until it is thoroughly dry, when it is 'fired' and burnt off. The stumps alone remain after the fire has swept over the land, and as these are of soft timber they decay in the course of a few years. Cotton is hand-sown in the ground between the stumps, thereby enabling the selector to obtain a cash return from the land within one year of when clearing commenced. No weeding is necessary during the first season, as the fire destroys all weed and grass seeds, and the need of cultivation in order to conserve moisture is also lessened, as the wood ashes form a sort of natural surface mulch on the ground.

It is further advisable to cut all trees off close to the ground level, and not to leave the stumps waist-high, as is so often the practice. Leaving high stumps facilitates the clearing of

THE IMMIGRANTS' FIRST HOME ON NEWLY BURNT-OFF SCRUB LAND, WITH COTTON GROWING BETWEEN THE OLD STUMPS.

the land in the first instance, but the stumps become a nuisance in following seasons and render cultivation a matter of difficulty until they have decayed. If no high stumps are left, a stump-jump plough may be used, and this greatly simplifies the cultivation of the land during following years.

Future Prospects.—The steady and rapid increase in the size of the cotton crop, the eminently suitable climate and rainfall, the length of the growing season and the good quality of the cotton produced all point to further expansion of the Australian cotton industry.

As long as the areas under cotton are confined to those which growers and their families can handle without engaging outside help, the cost of labour will not enter into the question, and Australia's white population must prove an asset, as with their intelligent assistance the production and the propagation of good quality cotton will be simplified.

The time, the cost and the labour which a grower has to expend on bringing a cotton crop to maturity remain practically the same whether the cotton produced is of good or bad quality, as in either case the plants require the same attention. The charges for picking, ginning, handling and freight are based on so much per pound, and are quite irrespective of whether the cotton has a high or low commercial value. Thus, not only will a control over the distribution of pure, good quality seed benefit the grower by returning him a higher rate of interest on his crop and the labour that he has expended, but it will also reduce the cost of production as compared to other cotton-producing countries. For, as the value of the crop produced increases, so the cost of producing it proportionately decreases, leaving a wider margin in hand with which to meet a fall in the value of the raw material, or foreign competition.

The cotton grown in India, China and parts of Africa is of poor quality. This may be directly attributed to the fact that coloured races are unable to bring to bear the same knowledge, science and systematic intelligence as the white man. White labour may be expensive, but at least it is efficient ; and although Australia may be unable to compete with black races in the production of poor quality cotton, she stands in a unique position, owing to her white population, when it comes to a question of quality.

Australia has made a commercial success of wheat growing ; by systematic and scientific breeding she has made her

wool, which in the early days was of poor quality, the finest in the world : if the right steps are taken she will achieve the same result with her cotton. For, just so long as Australia concentrates on quality production, she will have no cause to fear foreign competition, but quality, and the best quality at that, must be insisted on, if her white population, with their high standard of living, are to make a permanent success of cotton-growing.

APPENDICES

APPENDIX I

Egyptian Temperatures and Soil Analyses

The following summary of the life history of cotton in Egypt, which includes the temperatures, the dates of flowering, the period of growth and analyses of various soils, is included in this book, as the information may prove of interest in the future with relation to the growing of cotton in certain portions of Australia.

The author is greatly indebted for many of the facts and figures relating to cotton in Egypt to Mr. R. S. Sennitt, B.Sc., late of the Egyptian Ministry of Agriculture, who was for many years in charge of the field operations and the scientific breeding of cotton carried out by the Egyptian State Domains.

Temperatures have been obtained from the Ministry of Public Works (Physical Department), Cairo, Egypt.

The life history of the cotton plant in Egypt is based on practical experience obtained by large scale field operations carried out by the State Domains at Sakha, which is situated approximately in the centre of the Nile Delta in Lower Egypt.

Sakellaridis Cotton at Sakha. *Dates of Sowing.*—Sowing is more or less general from March 1 to March 31, the optimum sowing period being about March 15. Re-sowing occurs from about March 20 to April 30, but naturally the period between sowing and re-sowing depends to a great extent upon weather conditions at the time of sowing. If planting has occurred early in March, the period between sowing and re-sowing varies from 20 to 25 days, but if late in March the period is from 18 to 22 days.

Area Planted.—The total area of cotton sown annually in the Sakha tafteesh is about 2100 feddans (a feddan is equal to 1·038 acre); but the whole area of cotton sown and controlled by the State Domains amounts to about 10,000 feddans.

Appearance of Plants above the Soil.—This largely depends on the weather and the date of planting, but, generally speaking, the average period from the date of sowing to the very first appearance of the plants just above the ground may be taken as from 7 to 10 days under good climatic conditions.

Formation of first squares, about May 15.
Formation of first flowers, about June 10.

Formation of bolls, just after flowers appear.

Bursting of first bolls, about July 30.

Bursting of bulk of bolls, about August 31.

First picking, from September 10 until October 5.

Second picking, from October 5 until November 1.

Third picking (if any) commences as soon as second picking is finished.

The records relating to Bahtim are the result of accurate data that have been very carefully taken. Bahtim is an experimental farm belonging to the Sultanic Agricultural Society, and is situated about 10 miles north of Cairo.

Sakellaridis Cotton at Bahtim.—Date of sowing, about March 1.

Appearance of plants above soil, 15 to 20 days after sowing.

Formation of first squares, about 76 days after sowing.

Average number of days from square to flower, 26 days, with a range from 22 to 30 days.

Average number of days from flower to opening of boll, 53 days, with a range from 26 to 60 days according to time of planting and climatic conditions.

The warmer the weather the more quickly the bolls open after the formation of the flowers.

First picking commences about September 1.

Second picking commences about October 1. There is generally no third picking.

Average height of Sakel plants, 90 to 95 cm. (35·43 to 37·40 inches).

Average number of nodes, 29 to 30.

Average number of flowers per plant, 30.

Average number of bolls per plant (including sound, attacked, green and dead bolls), 16 to 17.

Average yield per feddan, 4½ to 5 kantars.

Soil Analysis.—The great majority of the soil of the Nile Delta is considered to be very suitable for cotton, and whilst some districts produce a better quality of cotton than others, these latter will often give a greater yield, thereby compensating for the slightly inferior quality of the cotton produced. Although it is hard definitely to state which is the best soil, it is generally considered that a *blackish medium loam* soil, such as one finds in many parts of Menufia province, is better suited to cotton than the heavier or lighter types of Egyptian soil. Again, climatic conditions affect the quality of the cotton to a very great extent, and it is thought that one of the reasons why the Tantah and Sakha districts of the Nile Delta produce cotton of such good quality is that, in addition to possessing a fertile soil, these districts are not far away from the coast, and therefore come under the influence of the moist sea breezes.

The salt-content of the soil is also of interest, for there is a

connection between the amount of *salt* that the soil contains and the strength of the fibre. Up to a certain percentage of salt is beneficial, but what this percentage amounts to has yet to be proved.

In order to give a fairly representative idea of the composition of the soils found in the Nile Delta of Lower Egypt, four places have been chosen—namely, Qalioub, just north of Cairo; Tantah, representing the centre of the Delta; Mansourah, in the north-east; and Damanhour, in the north-west.

The following pages give the physical and chemical analyses of Egyptian soils, and are obtained from the 'Report on the Manurial Trials on Cotton, 1908,' by Frank Hughes, F.C.S., *Khedivial Agricultural Society Year Book,* 1909, since when no further private or Governmental publications relating to the analyses of Egyptian soils appear to have been issued.

Qalioub

Physical Analysis of Soil, 0·30 cm.

	Dried at 100° C.	Ignited.
Moisture	4·93	4·93
Soluble matter	7·16	7·16
Loss on ignition	—	9·90
Coarse sand	2·33	2·18
Fine sand	20·85	19·67
Silt	16·67	15·83
Fine silt	28·24	26·34
Clay	17·19	15·33
	97·37	101·34

Water retaining power, 51·3 per cent.

Chemical Analysis of Soil, 0·30 cm.

	Per Cent.
Insoluble matter and silica	57·15
Oxide of iron and alumina	25·72
Lime	4·38
Magnesia	0·54
Potash	0·80
Phosphoric acid	0·27
Carbonic acid	2·81
Total nitrogen	0·06
Organic carbon	0·53
Loss on ignition after re-carbonation	6·40
Soluble in 1 per cent. citric acid :	
Silica	0·218
Potash	0·016
Phosphoric acid	0·029
Surface soil, 0·30 cm. :	
Total soluble salts	0·22
,, sodium chloride	0·04
Subsoil, 75–80 cm. :	
Total soluble salts	0·37
,, sodium chloride	0·08

YIELD AND GINNING OUT-TURN, QALIOUB

Variety.	Yield per Feddan in Kantars.	Ginning Out-Turn.	Weight of 100 Seeds.	Fibre per 100 Seeds.
Abbassi	4·37	100·2	11·36	5·23
Jannovich	3·84	97·5	13·10	5·31
Afifi	3·36	104·4	11·53	5·78

Interval from sowing to first picking, *198 days.*

Manshiet Hamad (Tantah)

Physical Analysis of Soil, 0·30 cm.

	Dried at 100° C.	Ignited.
Moisture	7·64	7·64
Soluble matter	4·48	4·48
Loss on ignition	—	7·79
Coarse sand	1·07	0·99
Fine sand	8·80	8·64
Silt	10·69	10·31
Fine silt	27·84	25·72
Clay	39·40	34·46
	99·92	100·03

Water retaining power, 53·6 per cent.

Chemical Analysis of Soil, 0·30 cm.

	Per Cent.
Insoluble matter and silica	57·20
Oxide of iron and alumina	28·44
Lime	2·44
Magnesia	1·03
Potash	0·63
Phosphoric acid	0·22
Carbonic acid	0·42
Total nitrogen	0·061
Organic carbon	0·83
Soluble in 1 per cent. citric acid:	
Silica	0·292
Potash	0·117
Phosphoric acid	0·025
Surface soil, 0·30 cm.:	
Total soluble salts	0·14
,, sodium chloride	0·04
Subsoil, 75–80 cm.:	
Total soluble salts	0·16
,, sodium chloride	traces

YIELD AND GINNING OUT-TURN, TANTAH

Variety.	Yield per Feddan in Kantars.	Ginning Out-Turn.	Weight of 100 Seeds.	Fibre per 100 Seeds.
Abbassi	5·28	107·8	11·07	5·75
Jannovich	4·89	105·2	11·51	5·78
Afifi	5·21	110·2	11·27	6·08

Interval from sowing to first picking, *178 days.*

Mansourah

Physical Analysis of Soil, 0·30 cm.

	Dried at 100 C.	Ignited.
Moisture	4·67	4·67
Soluble matter	5·55	5·55
Loss on ignition	—	9·38
Coarse sand	3·02	2·70
Fine sand	12·08	11·82
Silt	12·19	11·62
Fine silt	27·52	24·61
Clay	34·24	29·69
	99·27	100·04

Water retaining power, 59·9 per cent.

Chemical Analysis of Soil, 0·30 cm.

	Per Cent.
Insoluble matter and silica	56·56
Oxide of iron and alumina	23·97
Lime	3·82
Potash	0·63
Phosphoric acid	0·19
Carbonic acid	1·28
Total nitrogen	0·107
Organic carbon	0·90
Soluble in 1 per cent. citric acid :	
Silica	0·33
Potash	0·033
Phosphoric acid	0·021
Surface soil, 0·30 cm. :	
Total soluble salts	0·32
,, sodium chloride	0·16
Subsoil, 75–80 cm. :	
Total soluble salts	0·64
,, sodium chloride	0·32

YIELD AND GINNING OUT-TURN, MANSOURAH

Variety.	Yield per Feddan in Kantars.	Ginning Out-Turn.	Weight of 100 Seeds.	Fibre per 100 Seeds.
Abbassi	5·58	107·4	10·92	5·42
Jannovich	6·42	102·8	11·44	5·44
Afifi	5·72	107·0	11·61	6·18

Interval from sowing to first picking, *192 days.*

Damanhour

Physical Analysis of Soil, 0·30 cm.

	Dried at 100 C.	Ignited.
Moisture	5·74	5·74
Soluble matter	3·46	3·46
Loss on ignition	—	9·52
Coarse sand	4·21	3·94
Fine sand	22·59	21·48
Silt	17·79	16·90
Fine silt	24·01	22·25
Clay	19·35	17·33
	97·15	100·62

Water retaining power, *50·8 per cent.*

Chemical Analysis of Soil, 0·30 cm.

	Per Cent.
Insoluble matter and silica	58·95
Oxide of iron and alumina	25·49
Lime	3·88
Magnesia	0·65
Potash	0·89
Phosphoric acid	0·31
Carbonic acid	1·18
Total nitrogen	0·093
Organic carbon	0·87
Soluble in 1 per cent. citric acid :	
Silica	0·3
Potash	0·029
Phosphoric acid	0·088
Surface soil, 0·30 cm. :	
Total soluble salts	0·28
,, sodium chloride	0·17
Subsoil, 75–80 cm. :	
Total soluble salts	0·38
,, sodium chloride	0·21

YIELD AND GINNING OUT-TURN, DAMANHOUR

Variety.	Yield per Feddan in Kantars.	Ginning Out-Turn.	Weight of 100 Seeds.	Fibre per 100 Seeds.
Abbassi	3·38	103·7	11·04	5·19
Jannovich	1·76	97·0	11·21	4·99
Afifi	2·86	104·2	10·35	5·10

Interval from sowing to first picking, *181 days.*

In Upper Egypt a shorter and coarser variety of cotton, known as Achmouni or ' Upper,' is cultivated on the land in the immediate vicinity of the Nile, but, with the exception of the Fayum district, cultivation does not extend very far from the river banks.

Achmouni cotton is generally sown about the second or third week in February, and picking commences about the third week in August. Accurate detailed information concerning the growth of the cotton plant in Upper Egypt does not appear to be available, as neither the Ministry of Agriculture nor private agricultural societies seem to have gone into the matter.

Temperatures.—Owing to the limited number of Meteorological recording stations in Egypt it is only possible to obtain the temperatures of certain places, but the figures given in the four following tables—namely, Minya, in Upper Egypt; Giza, near Cairo; Qorashiya, some six miles north-east of Tantah; and Sakha, in the approximate centre of the Nile Delta—may safely be taken as representative of the various parts of the country.

Maximum Temperature.—This has been obtained by taking the maximum temperature of every day during the month for all the period considered and divided by the number of days.

Minimum Temperature.—Obtained in the same manner as the maximum temperature.

Mean of Day.—For Sakha, Qorashiya and Giza, where three observations are taken daily, the mean average monthly temperature has been obtained by adding the records taken at 8 A.M., 2 P.M., 8 P.M. and the minimum temperature and dividing by 4. This is the acknowledged way for a mean of day to be procured from stations where observations are taken three times a day.

At Minya in Upper Egypt only one observation was taken daily at 8 A.M.; consequently the mean of the day is the average of

$$\frac{\text{Max.} + \text{Min.}}{2}.$$

Hottest Day.—This is the absolute maximum obtained in that month during the period of years considered.

Coldest Day.—Arrived at in a similar manner to the hottest day.

Relative Humidity.—This is the average of the 8 A.M. and 8 P.M. observations in percentage for the period concerned.

The mean average maximum, minimum, and the mean of day temperatures for the period of growth, March to August, are given in the final column of the following tables:—

MINYA (UPPER EGYPT)

LAT. 28° 6′ N. LONG. 30° 46′ E. 1907–1920

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	March to August.
Relative Humidity 8 A.M.	79%	75%	71%	62%	59%	61%	63%	67%	74%	76%	77%	80%	70%	64%
Maximum Temp.	66·9°	70·3°	77·5°	86·7°	92·6°	97·3°	98·2°	96·08°	89·4°	84·3°	77·0°	68·7°	83·8°	91·4° Fahr.
Minimum Temp.	43·1°	44·6°	49·1°	56·1°	61·7°	66·7°	69·4°	69·8°	67·1°	63·1°	55·2°	46·4°	57·7°	62·2° Fahr.
Hottest Day	86·0°	91·4°	103·1°	107·7°	113·7°	116·2°	110·3°	106·7°	101·8°	103·1°	99·5°	84·02°	...	...
Coldest Day	32·7°	34·8°	35·4°	43·5°	50·0°	55·4°	62·06°	63·3°	56·6°	51·8°	41·0°	36·3°	...	...
Mean of Day	55·04°	57·5°	63·3°	71·4°	77·1°	82·04°	83·8°	82·9°	78·2°	73·7°	66·2°	57·56°	70·7°	76·8° Fahr.

GIZA (NEAR CAIRO)

LAT. 30° 2′ N. LONG. 31° 13′ E. 1902–1920

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	March to August.
Relative Humidity Mean of Day	80%	73%	69%	61%	55%	56%	61%	67%	73%	75%	78%	81%	69%	62%
Maximum Temp.	66·3°	69·6°	75·02°	82·5°	89·06°	93·5°	95·1°	93·7°	88·7°	85·1°	77·3°	69·08°	82·04°	88·1° Fahr.
Minimum Temp.	41·9°	43·3°	46·9°	52·7°	57·9°	63·5°	66·9°	67·6°	63·8°	60·2°	53·4°	45·8°	55·4°	59·3° Fahr.
Hottest Day	85·6°	92·4°	100·5°	109·04°	112·4°	114·4°	106·8°	107·06°	104·7°	106·7°	98·6°	82·5°	...	...
Coldest Day	36·5°	32·7°	33·8°	39·2°	46·9°	53·9°	59·0°	60·9°	54·5°	50·3°	40·1°	39·2°	...	...
Mean of Day	51·6°	54·1°	59·3°	66·2°	72·6°	77·7°	79·8°	79·3°	75·02°	70·88°	63·1°	54·8°	67·1°	72·5° Fahr.

QORASHIYA (NILE DELTA)

Lat. 30° 51′ N. Long. 31° 7′ E. 1907–1920

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	March to August.
Relative Humidity Mean of Day	86%	83%	79%	71%	64%	64%	69%	75%	77%	82%	85%	87%	77%	70%
Maximum Temp.	66·5°	68·3°	74·1°	81·5°	89·06°	94·4°	96·08°	95·0°	89·9°	85·1°	77·3°	69·0°	82·4°	88·3° Fahr.
Minimum Temp.	40·4°	41·7°	45·6°	50·3°	55·4°	61·3°	64·7°	65·3°	61·5°	57·9°	51·8°	44·4°	53·4°	57·2° Fahr.
Hottest Day	82·7°	84·2°	100·04°	103·2°	113·5°	117·4°	107·2°	105·2°	103·2°	100·2°	98·6°	82·5°	...	...
Coldest Day	...	...	35·2°	39·2°	44·6°	48·9°	57·2°	58·1°	53·9°	49·2°	38·8°	32·3°	...	...
Mean of Day	50·7°	52·8°	58·1°	64·4°	71·06°	76·8°	79·3°	78·8°	74·4°	69·9°	62·4°	54·3°	66·2°	71·4° Fahr.

SAKHA (NILE DELTA)

Lat. 31° 7′ N. Long. 30° 57′ E. 1907–1920

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	March to August.
Relative Humidity Mean of Day	84%	84%	83%	75%	72%	70%	73%	79%	78%	81%	84%	86%	79%	75%
Maximum Temp.	64·9°	67·1°	71·8°	80·06°	87·08°	92·1°	93·3°	93·02°	89·2°	84·5°	77·0°	68·0°	80·6°	86·1° Fahr.
Minimum Temp.	42·4°	42·4°	45·3°	49·6°	54·6°	60·08°	63·5°	64·04°	61·5°	56·8°	51·8°	44·6°	53·0°	56·3° Fahr.
Hottest Day	84·2°	82·9°	94·3°	101·3°	111·02°	112·6°	107·7°	105·6°	99·5°	99·5°	99·1°	83·3°	...	...
Coldest Day	34·5°	32·9°	34·3°	36·6°	40·1°	46·7°	50·0°	54·5°	52·1°	40·4°	38·3°	36·3°	...	...
Mean of Day	51·1°	52·3°	56·3°	63·1°	69·2°	75·2°	77·7°	77·3°	74·1°	69·6°	62·2°	54·1°	65·1°	69·8° Fahr.

Egyptian Weights and Measures.

1 Ardeb = 198 litres = $\left(\begin{matrix}43\cdot58 \text{ gallons}\\5\cdot45 \text{ bushels}\end{matrix}\right)$ = 2·7 kantars (of cotton seed).

1 Feddan = 4200·8 square metres = 0·42 hectares = 1·038 acres.

1 Kassabah = 3·55 metres = 3·88 yards.

1 Oke = 1·25 kilos = 2·75 lb. (English).

1 Kantar = $\left(\begin{matrix}100 \text{ rotls}\\36 \text{ okes}\end{matrix}\right)$ = 44·93 kilogr. = 99·05 lb. (English).

1 acre for all practical purposes = 1 feddan ; the exact equivalents are : 0·936 feddan or 0·40467 hectares.

1 Egyptian £ = £1 0*s*. 6¾*d*. sterling = Frs. 25·92.

1 £ sterling = 97½ P.T. (Piastre Tarif).

1 £ E. = 100 piastres = 1000 millièmes.

1 piastre = 2·46*d*. = 25·9 centimes = 10 millièmes.

1 millième = 0·246*d*. = 259 centimes.

1000 millièmes = 1 £ E. = £1 0*s*. 6¾*d*. = 25·92. Frs.

APPENDIX II

DISEASES OF THE COTTON PLANT

PHYSIOLOGICAL AND BACTERIAL DISEASES

Reprinted from the *Agricultural Gazette* of New South Wales, November and December issues, 1923, by courtesy of the authors, W. A. Birmingham, Assistant Biologist, and I. G. Hamilton, B.Sc., British Australian Cotton Association, Limited.

Owing to the increasing importance of the cotton crop in New South Wales, and the likelihood of its playing a greater part in our agriculture in the near future, a brief review of the pathological diseases to which it is liable seems opportune.

At present our knowledge of the diseases of cotton in Australia is strictly limited ; but by presenting a short account of those which affect this plant in other countries (some of which we know also to be present in our State), it is hoped to stimulate the interest of all having to deal with the crop and to secure their aid in as quickly as possible building up local knowledge.

During the coming season it is hoped to secure information which will enable us to determine the exact nature and distribution of what are going to prove our most formidable diseases. In carrying this into effect it is hoped to secure the co-operation of growers, who are requested to forward samples of any diseased condition that may appear Whole plants packed in cardboard boxes should be sent, if possible, consigned to the Biological Branch, Department

of Agriculture, Mining Museum, George-street North, Sydney. Together with the sample, as much information as possible throwing light on the following points should also be forwarded :—

1. The severity of the attack.
2. Other occurrences of a similar nature in the neighbourhood.
3. The parts of the plant showing the diseased condition ; a sample of each part should be forwarded to the Biological Branch if it is impossible to send the whole plant.
4. A description of the exact location of the field or part of field containing the affected plants.
5. When the disease was first observed and the kind of weather which immediately preceded its appearance.
6. The nature of the soil and subsoil, especially with regard to moisture.
7. The cultivation and manuring of the field.

In the meantime, the grower is reminded that correct cultural methods play a large part in maintaining the health of a crop, and hence in lessening its liability to attack.

The following is a list of the fungous and other diseases which affect the cotton plant :—

(*a*) Physiological Diseases.—(1) Boll-shedding, (2) 'Rust' (so-called), (3) Club Leaf or Cyrtosis, (4) Blue Cotton.

(*b*) Bacterial Diseases.—(1) Angular Leaf Spot (*Bacterium malvacearum*), (2) Crown Gall (*Pseudomonas tumefaciens*).

(*c*) Fungoid Diseases.—(1) Anthracnose (*Colletotrichum gossypii* South), (2) Wilt (*Fusarium vasinfectum*), (3) Texas Root Rot (*Ozonium omnivorum* Shear), (4) Sore Shin (*Corticium vagum* B. & C. var. *Solani* Burt), (5) Internal Boll Disease, A., B., C. & D. Nowell, (6) Southern Blight (*Sclerotium rolfsii* Sacc.), (7) Leaf Spot or Blight (*Cercospora gossypina* Cke.), (8) False or Areolate Mildew (*Ramularia areoli*, Atk.), (9) Rust (*Uredo gossypii* Atk.), (10) Mildew (*Oidium* sp.), (11) Diplodia Boll Rot, (12) Fusarium Boll Rot, (13) Leaf Blight (*Alternaria* sp.), (14) *Hymenochætæ noxia* Berk, (15) *Phyllosticta malkoffi* Bub., (16) *Phoma roumii*. Trau.

(*d*) Eelworm (*Heterodera radicicola*).

Boll-shedding.—This represents a serious loss of crop in every cotton-growing country ; in fact, with regard to the United States, Gilbert says, 'In the aggregate the loss from shedding is greater than that from all the cotton diseases combined. Loss of 40 to 60 per cent. of bolls is a fairly common occurrence.' Harland, with regard to the West Indies, says : 'The chief loss of crop is due to the shedding of bolls and buds.' In Egypt, Balls says, boll-shedding is a 'matter of great economic importance,' the actual loss being about 40 per cent. The bolls shed vary in age considerably, from one or two days old to nearly mature bolls. In Egypt, the bulk of the loss from this

Fig. 1.—Branch of a Chinese Cotton Plant affected by Club Leaf (Cyrtosis).

In the lower part the internodes are of normal length and leaves of normal size and shape, but change abruptly in the upper part to the short internodes and distorted leaves that characterise the disorder.—[*After Cook.*]

cause is due to the falling of the very immature organs three or four days after the opening of the flowers. Bell says, ‘ Ripening bolls, up to 2 centimetres in diameter, may be shed, but this is less common.’ In the United States and West Indies the shedding is chiefly of more mature organs, beginning about a week after the flowering period and gradually increasing as the season advances. Harland says, ‘ According to Balls, boll diseases are almost unknown in Egypt, whereas in St. Vincent they are the chief agents responsible for the heavy shedding of bolls.’

Nowell gives a very good general statement of the causes leading to boll-shedding : ‘ It has been established that shedding occurs when from any cause whatever the amount of water taken in by the roots falls short of that which is given out by the leaves. Undue exposure to the wind, caking of surface soil, drought, root interference, root pruning by cultivation, excessive vegetative growth brought on by rain during the flowering period, and the asphyxiation of the roots in water-logged soil are all capable of bringing about boll-shedding.’

Rust (so-called), Yellow Leaf Blight and Potash Hunger.—This is a purely physiological condition, characterised by the production of reddish-coloured leaves, which drop off prematurely. In severe cases the plants may be stripped of their leaves, leaving only the bare stalks. The cotton produced by rusted plants is very weak and inferior. Harland, in carrying out manurial experiments with Sea Island cotton in the West Indies, found that it was only those plots which were not treated with potash manure which showed this affection. The obvious remedy, therefore, is to supply potassium to land which grows ‘ rusted ’ cotton plants.

Club Leaf or Cyrtosis.—This is a peculiar disease of cotton plants in China, which was investigated by O. F. Cook in 1920. No causal organism has so far been discovered, so that the disease is for the present classified as a physiological one.

Recognition.—The plants in an affected area are modified in every possible part of their structure—the leaves are reduced in size, discoloured, and distorted, the petioles and internodes are shortened and the branching habit changed (see Fig. 1).

Cause.—The condition may be of the nature of a mosaic disease or of a leaf curl, the infective agent being transmitted by plant lice. The disease is not seed-borne.

Control.—Club leaf is most injurious during hot weather at the height of the fruiting season, so that early planting to ripen the crop quickly is likely to be efficacious. There is also a possibility of breeding out resistant varieties.

Blue Cotton.—Blue cotton is a peculiar condition of cotton which occurs to a limited extent on the Sea Islands and in Florida. It is characterised by the deep green or bluish colour of the leaves, the prostrate habit of the plant, and the shedding of the fruit. The

use of organic manures appears to aggravate the trouble. On the Sea Islands the use of salt, mud, and lime, and also drainage, have been found to have a remedial effect.

Angular Leaf Spot (*Bacterium malvacearum* E. F. Sm.).—Variously known as bacterial blight, bacterial boll-rot, black-arm, or angular leaf spot, this disease is of more or less importance according to climatic conditions. It is very widely distributed, being known to occur in the United States, the Philippines, Nyasaland, Egypt, China, Barbados, Turkestan, and Pretoria.

FIG. 2.—BACTERIAL BOLL-ROT OF COTTON (*Bacterium malvacearum*). [*After Gilbert.*]

Damp, low-lying situations appear to favour the disease. The amount of damage which it does varies from nil to as much as 75 per cent. or more in severe cases.

Recognition.—Its greatest damage is done to the bolls. The first signs are small, dark-green, water-soaked, roundish spots on the bolls, which gradually enlarge and turn black in the centre as the tissues are killed and shrink (Fig. 2). Frequently two or three loculi of the entire boll are so injured that they fail to open, or if they do the fibre is found to be discoloured and rotten. Often the boll pedicel is attacked and killed, so that the boll dries up and either falls off before maturity or fails to open.

The most general and conspicuous evidence of the disease is given by the angular spots on the leaves. The spots never cross the larger veins, hence their angular form (Fig. 3).

The stems may also be attacked, when the external skin is killed and the branches turn black, hence the name ' black-arm.' It also

causes a wilting-off of the seedlings similar to that caused by 'sore shin.' The wilting produced by angular leaf spot may be distinguished by being more sudden and by the water-soaked appearance of the attacked portion.

Cause.—The disease is caused by a rod-shaped bacterium, *Bacterium malvacearum.* The organism gains entrance into the plant through the stomata or through injuries. It may live on the seed and lint for at least four months, and also in the soil for a considerable period.

FIG. 3.—ANGULAR LEAF SPOT OF COTTON (*Bacterium malvacearum*).
[*After En. Smith.*]

Control.—(1) Sterilisation of the seed. This treatment is usually only used for special seed, being too expensive for general use. The lint is first removed with concentrated sulphuric acid, and then the seed is treated with hot water at 72° C. (161° F.) for eighteen minutes or with mercuric bichloride (1 part in 1000 parts of water) for one hour. Earthenware vessels or wooden vessels coated with melted roofing pitch should be used for treatment with sulphuric acid. (2) Seed from disease-free fields only should be used.

Crown Gall (*Pseudomonas tumefaciens* S. & T. Stev.).—Crown gall is of very little economic importance as regards the cotton plant. It forms natural galls on this as well as on numerous other plants. The outgrowths are formed at about the level of the ground and on the main roots.

FUNGOID DISEASES

Anthracnose (*Glomerella gossypii* Edg., syn., *Colletotrichum gossypii* South.).—Cotton anthracnose, boll-spot, or boll-rot occurs throughout the cotton belt in the United States, where its seriousness varies according to the season.

It is a serious disease on cotton in the Philippines, while in Egypt it is not serious though it is very common. Mr. W. L. Waterhouse has recorded it from Hawkesbury Agricultural College. In America the annual loss is estimated to amount to several million dollars. Wet seasons are very favourable to the spread of the disease. The damage which the disease is responsible for includes the killing of seedlings, the entire and partial destruction of the bolls, the discoloration of the lint, and injury to the stems and boll pedicels. Occasionally the loss on individual farms is as great as 80 or 90 per cent., while on adjoining places little trouble is experienced.

Recognition.—The parts of the plant on which the disease manifests itself are the bolls (Fig. 4), the young seedlings, the stems, and the boll pedicels. The boll injury is probably the most serious. At first small reddish or reddish-brown spots with a slight shrinking of the tissue in the centre may be observed. The spots gradually change, the centres becoming black, while the rims remain reddish. The spots may coalesce until they involve a large portion of the boll. If the bolls are attacked young they may be peculiarly dwarfed, or may crack open, exposing the immature fibre to the weather and further destruction. When more mature bolls are attacked, only a part (one or two loculi or divisions) may be destroyed.

Fig. 4.—Boll attacked by Anthracnose.

In young seedlings anthracnose has a ‘ damping off ’ effect, attacking the young plants at about the surface of the ground and causing them to collapse.

When the boll pedicel or stalk is attacked the result is usually the falling-off of the boll. Stems frequently develop lesions due to anthracnose attack.

Cause.—The causal organism is the fungus *Glomerella gossypii* Edg. It propagates itself by two kinds of spores, one of which is responsible for the characteristic pink coloration. Anthracnose is spread by insects and by the wind, and it is also carried in or on the seed. Spores of this fungus are left in the cotton gin by badly diseased

lots of cotton, the result being that seed otherwise free from the disease becomes infected.

Controls.—1. Use disease-free seed for planting—that is, seed from a field free from disease.

2. Crop rotation—a two-year rotation is necessary to free the field entirely of disease.

3. Seed treatment with sulphuric acid and mercuric chloride is useful for small lots of select seed. It is too expensive for general use.

FIG. 5.—SEA ISLAND COTTON, A VARIETY RESISTANT TO WILT DISEASE. The result of selection from resistant plants.—[*After Orton.*]

4. Grow varieties least troubled by the disease. No commercial varieties are known which are absolutely resistant, but a number are known which are not troubled by it to any great extent. Harland, referring to the various cotton plants he grew in the West Indies, says: 'Certain of the types of cotton grown at the Experiment Station show resistance to the angular leaf disease which is quite definitely genetic. What must be aimed at is to synthesise (breed) a new type of cotton combining the desirable qualities of Sea Island cotton with the disease-resistance of these otherwise undesirable varieties.'

Cotton Wilt or Black-root (*Fusarium vasinfectum* Atk.).—Wilt occurs to a greater or less extent in every cotton-producing State in America. Its attacks have been most serious in the sandy soils from

Virginia to Texas. The amount of damage which it is responsible for varies in different seasons, it being more severe in wet seasons than in dry ones. In severe cases the yield is reduced as much as 75 to 90 per cent. Gilbert estimates that the annual loss in the

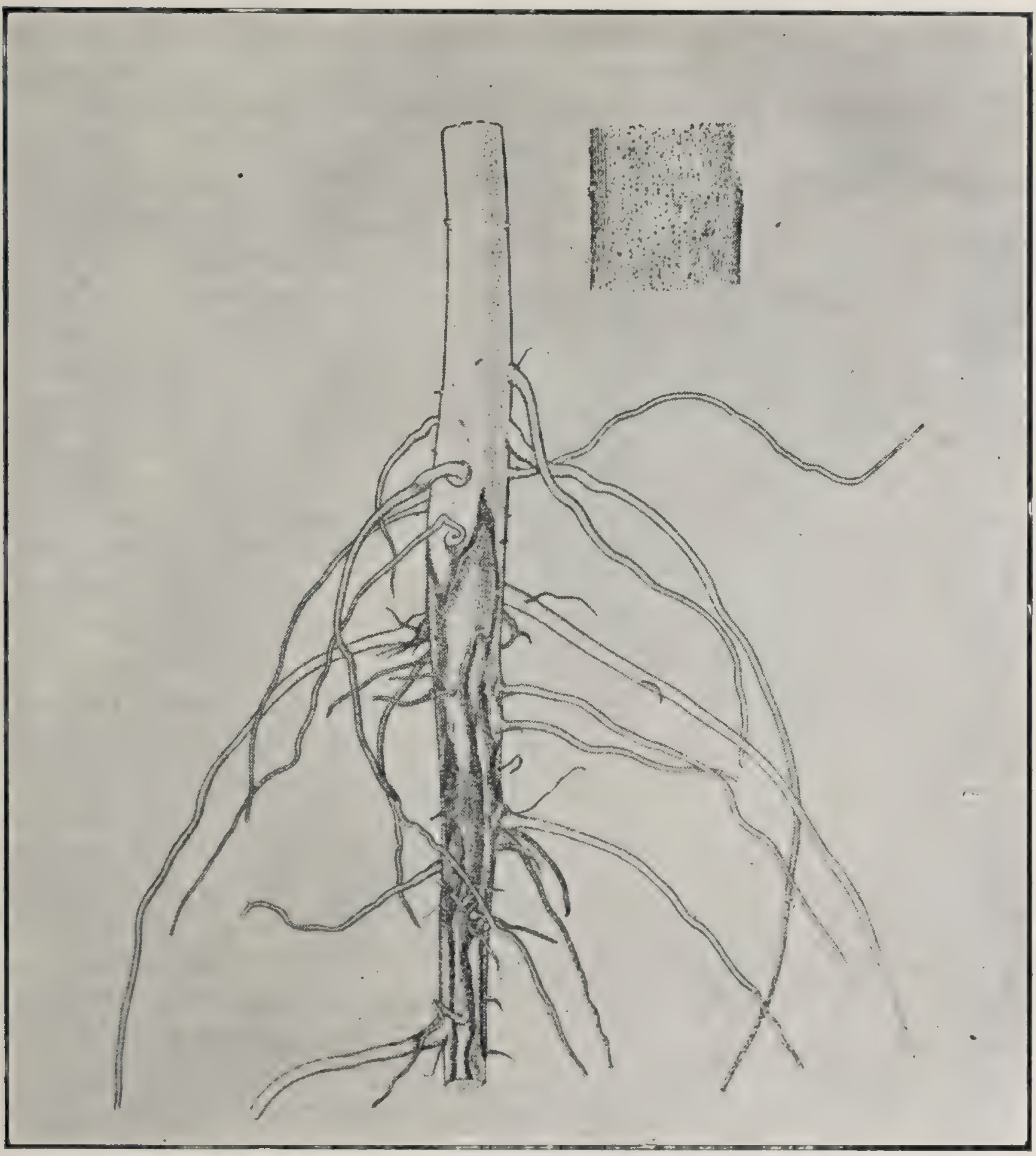


Fig. 6.—Cotton Root-rot.

Affected plant with bark removed from base of stem and roots, × $\frac{2}{3}$. Above, part of surface of wood showing sclerotia of Rhizoctonia, × 2.—[*After Butler.*]

American cotton belt due to wilt amounts to at least ten million dollars.

Recognition.—When the leaves of the cotton plant wilt and fall without any apparent reason, black-root or wilt is to be suspected. If the interior of the stem or root of a freshly wilted plant is found to be browned or blackened, the disease is almost sure to be wilt.

A dwarfing of the main stem is also characteristic of the disease. Affected plants ultimately die (see Fig. 5).

Cause—The causal organism is *Fusarium vasinfectum.* The fungus gains entrance into the roots from the soil, usually by means of an injury. It grows in the large vessels of the root and stem, blocking them up and causing them to turn black. The blocking of the vessels is the direct cause of the external evidence (the wilting and dwarfing) of the presence of the disease, as the free interchange of raw food material and manufactured food between root and stem is thereby interfered with. The fungus reproduces itself by several types of fruiting bodies, and its dispersal may be carried out by the wind blowing the spores, or by soil, parts of affected plants and other material containing spores and mycelium being carried from field to field. Gilbert carried out tests, and found that cotton seed does not spread the disease.

Fig. 7.—Southern Blight.
Note the small brown seed-like sclerotia on carnation.

Control.—Several varieties have been bred out in America which are absolutely resistant to wilt. Such varieties are Dillon, Dixie, Dixie Triumph, and Dixie Cook. As the fungus is capable of living as a saprophyte on the decaying vegetable matter in the soil for from seven to ten years, the practice of a suitable rotation between these resistant varieties and other crops is the only satisfactory way of finally freeing the soil of the organism.

Texas Root-rot of Cotton (*Ozonium omnivorum* Sh., syn., *Phymatotrichum omnivorum* (Shear) Dugger).—Gilbert (1921) says that 'in Texas, root-rot is the most destructive disease of cotton, some planters regarding it a more serious menace to the crop than the cotton boll weevil. In 1906 the loss in Texas was estimated at 52,600 bales, or 1·3 per cent. of the crop.'

Recognition.—The first indication of the presence of this disease is the sudden wilting of one or more cotton plants. The roots are

at first covered with a whitish mould, which later becomes yellowish-brown. The tap-root is usually attacked first, at a point near the surface of the ground. It is quite common to find the tap-root entirely dead owing to the ravages of the disease, and a single abnormally developed lateral root supporting the plant.

FIG. 8.—LEAF-SPOT (*Cercospora gossypina*).

Cause.—The fungus responsible for the disease is known as *Ozonium omnivorum*. It lives in the soil, spreading underground from plant to plant, and penetrating the roots and causing the wood to turn black. The fungus appears to grow best where the soil aeration is poorest. Warm weather following rain is especially favourable to the spread of the disease.

Control.—No very satisfactory methods of control are known. The best method is probably the practice of a three-year rotation, combined with deep ploughing in the fall. *Ozonium omnivorum* attacks a large number of other plants besides cotton, so that immune crops must be used in the rotation. Among the immune crops are maize, sorghum, millet, wheat, oats, and other grasses.

Sore-shin (*Rhizoctonia solani* Burt., syn., *Corticium vagum* P. and C. var. *solani*).—Sore-shin, or damping-off, is one of the diseases of lesser importance in the United States, whereas in Egypt it is the

only serious fungoid disease of cotton. It has long been known in Europe, and is also known in North and South America, the West Indies, India, and Australia.

Recognition.—Sore-shin attacks the plants in the seedling stage, causing cankerous spots on the stems and roots. The spots result

Fig. 9.—False or Aerolate Mildew.

in a cessation of growth, in the yellowing of the leaves, and, if they encircle the stem, in death. Sometimes two or three replantings may be necessary.

Cause.—The causal organism was first described as a species of *Rhizoctonia* by Atkinson in the United States in 1895. It is now recognised as being identical with the organism which attacks potatoes as *Corticium vagum*. *Corticium* is capable of passing

long periods of time in a resting stage, produced by forming small dark knots of twisted mycelium. Balls worked out the relationship of the fungus to temperature, finding that below 33° C. (equal to 91° F.) the fungus grows freely, but above this temperature its growth becomes gradually slowed down until completely arrested.

FIG. 10.—ALTERNARIA SPOT ON COTTON LEAF.

Control.—As temperature above 33° C. arrests the growth of the fungus, it is important that sowing should take place when there is every chance of warm weather ensuing immediately after sowing to give the seedlings a good start. Treating the seed with 2½ per cent. of its weight of naphthalene mixed with gypsum as a cement is found to prevent an initial attack of sore-shin on the seedlings.

Internal Boll Disease.—This disease is especially prevalent in the West Indies, and according to Harland is the most important factor in causing boll-shedding. The evidence of the presence of the

disease is the gross staining of the lint in the unopened bolls, often followed by more or less rotting of the boll contents. The organisms responsible were examined by Nowell, who found in the great majority of cases that one or more of four fungi were responsible, and in some cases one or more species of bacteria. Nowell had described these four fungi and temporarily distinguished them as A, B, C, and D.

Experiments showed that the disease is dependent for infection

Fig. 11.—Alternaria Spot on Bolls.

upon the punctures of plant bugs, and evidence supports the opinion that the infecting organisms are carried by the bugs themselves.

Southern Blight (*Sclerotium rolfsii* Sacc.).—Southern blight is found on a large number of host plants as well as cotton in the Southern States. Affected plants lose colour, wilt, and may die. The causal fungus—*Sclerotium rolfsii*—is found around the base of the stem and on the roots, where one can recognise it by the dense mass of mycelium covered by a large number of the characteristic small, brown spherical bodies known as sclerotia (see Fig. 7).

Black Rust, Leaf-spot, or Blight (*Macrosporium nigricantium* Atk.), (*Cercospora gossypina* Cke., syn., *Sphaerella gossypina* Atk.). —Leaf-spot is not of any great importance economically. It is more common on the vigorous or old leaves, and is generally reported as prevalent when for any reason the vitality of the plant is lowered. The spots are at first small and red, later becoming pale, and finally brown at the centres. They are generally up to a quarter of an inch in diameter, but sometimes confluent and extensive (see Fig. 8).

False or Areolate Mildew (*Ramularia areola* Atk.).—This disease is of minor importance on cotton in India, the United States, the West Indies, and South Africa.

The causal organism—*Ramularia areola*—occurs chiefly on the older leaves as the plants reach maturity. It forms irregular pale translucent spots, from one-sixteenth to half an inch in diameter, and with a definite margin formed by the veins of the leaf (see Fig. 9). Later the leaf turns yellowish-brown, and a whitish, frosty growth appears, chiefly on the under surface, but occasionally also above.

Rust (*Uredo gossypii*, syn., *Kuehneola gossypii* (Lagerh) Arth.).—Rust is a widely spread disease, being known to occur in India, Ceylon, Java, West Africa, the West Indies, North and South America, New Guinea, and the Philippines. It appears to do very little damage, attacking chiefly sickly plants, which may be defoliated. Infected leaves are entirely covered on both surfaces with minute brownish to black pustules.

Diplodia Boll-rot (*Diplodia gossypina*).—This fungus has been responsible for up to 10 per cent. loss in some fields in Louisiana. It gains entry to the boll by means of insect injuries or wounds, but is not able to attack uninjured bolls. The bolls when first attacked become brown and later turn black, and are coated with a powdery mass of spores. The entire boll rots and the fibre is blackened and decayed.

Where the disease becomes serious, rotation of crops is recommended.

Fusarium Boll-rot (*Fusarium* sp.).—Bolls injured by insects or other diseases are attacked by this fungus, which can be recognised by its pink covering of spores produced over the entire surface of the affected area. Young seedling plants are also attacked.

It is not important except in wet seasons, when it may be prevalent. The fungus is carried in the seed and lives over winter in the field.

A species of *Fusarium*, similar to the above and recorded elsewhere, has been found in New South Wales.

A wilting of cotton seedlings has also been found in the State, associated with which a species of *Fusarium* has been repeatedly found.

Alternaria Leaf-spot (*Alternaria* sp.).—A species of fungus has been recorded on the cotton plant from South Carolina, India, and Australia. In New South Wales it has been found associated with spotting of the leaves and bolls (see Figs. 10 and 11). Mr. W. L. Waterhouse, University of Sydney, produced leaf-lesions on inoculations with a species of *Alternaria* isolated from cotton plants grown in New South Wales. Butler states, ‘ exotic cottons which are being unsuccessfully acclimatised in India are often invaded by a species of *Alternaria*.’

Recognition.—The spots may be pale green, then straw-yellow, of a brittle papery texture, with irregular, concentric ridged zones. It appears to be a weak parasite, and possibly attacks only plants whose vitality has been lowered owing to some unfavourable condition of soil or climate.

Control.—Destruction of diseased trash by burning and rotation of crops appear to be the most practical ways of reducing the fungus.

Some Other Diseases.—Mildew (*Oidium* sp.) on cotton is of rare occurrence in India, but common in the West Indies. The damage caused by it is only slight, as only old leaves are attacked. Yellow or red irregular patches appear on the leaves, which ultimately spread over the whole surface.

FIG. 12.—ROOT-KNOT ON SQUASH PLANT.

Hymenochaete noxia Burk., attacks an extremely wide range of plants throughout the eastern tropics. It has been reported as attacking Caravonica cotton.

Phyllosticta malhoffi Bub., causes leaf spots on cotton in Bulgaria.

Phoma roumii Frou., is a species of Phoma which is said to cause a serious cotton disease in Africa.

Root-knot (*Heterodera radicicola* (Greef) Mull.).—Root-knot is a well-known disease on a large number of crops besides cotton, and is widely distributed in New South Wales. The losses which it causes in some cases are as high as 80 per cent.

Recognition.—The plants are stunted but not noticeably deformed above ground, as is often the case with plants suffering from wilt. The leaves and stem take on a peculiar sickly yellowish-green colour. The root is found to be covered with galls (see Fig. 12), which interfere with the free interchange of material between root and stem. Plants affected with root-knot are rendered much more

liable to wilt owing to the wounds that are caused by the nematodes responsible for the root-knot forming an easy mode of access to the plant for the wilt fungus. Root-knot is essentially a disease of light soils, though it may occur on heavier soils than wilt.

Cause.—Tiny eelworms or nematodes (*Heterodera radicicola*) are responsible for root-knot. They bore into the roots from the soil and live there, causing minute swellings on the roots. On examination microscopically each of these swellings is seen to contain numerous individuals. The male worms are too small to be seen with the naked eye. The female worms when full of eggs assume a spherical shape and may often be distinguished. Each female may lay several hundred eggs.

Control.—Measures for the control of root-knot include the eradication of susceptible weeds and the practice of crop rotation. A two- or three-year rotation with immune crops is necessary to starve the nematodes out of badly infested land before a susceptible crop, such as cotton, can be successfully grown. Among the immune crops are barley, corn, certain varieties of cowpeas, grasses, millets, oats (winter), peanuts, rye, sorghum, and wheat.

APPENDIX III

NEW SOUTH WALES RAINFALL

It will be noticed that in most cases the rainfall figures given in Appendices III and IV do not absolutely agree with those shown in the diagrams contained in Chapters V and VI. These slight differences are accounted for by the fact that most of the diagrams were compiled from ‘ Rainfall Observations ’ that embrace periods ranging from 1840 to 1917, whereas the rainfalls given in Appendices III and IV include all records up to, and inclusive of, 1922.

In these Appendices the rainfall is shown in *points* ; 100 points being equal to 1 inch : *e.g.* 253 points are equivalent to 2·53 inch.

AVERAGE MONTHLY AND ANNUAL RAINFALL AT SELECTED STATIONS IN NEW SOUTH WALES.

As supplied by the Commonwealth Meteorologist, H. A. HUNT, Esq., F.R.M.S.

The heavier figures denote the 3 months in which the average monthly rainfall, is highest and include all records up to the end of 1922.

Station.	No. of Years' Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
WESTERN						**District Av. 1264**								
Angledool	33	**187**	**184**	147	104	123	155	122	84	111	124	108	**190**	1639
Balranald	44	57	83	79	91	**131**	**135**	87	**117**	113	110	104	88	1195
Barringun	41	**150**	**185**	113	106	113	**133**	102	87	76	105	125	133	1428
Bourke	50	**146**	**164**	123	118	106	119	92	84	81	100	122	**129**	1384
Brewarrina	48	**196**	**164**	148	108	106	**158**	108	93	114	101	119	121	1536
Broken Hill	34	71	86	59	72	**102**	**124**	72	**91**	80	89	70	82	998
Byrock	31	132	**163**	120	110	113	**140**	100	98	83	109	103	**145**	1416
Cobar	41	**146**	**134**	98	104	113	132	89	119	94	113	110	**146**	1398
Collarindabri	38	**201**	**202**	194	110	140	162	140	115	109	133	177	**222**	1905
Enngonia	31	**132**	**178**	104	106	105	**127**	84	88	88	105	121	123	1361
Euabalong	38	**156**	111	119	103	140	**156**	134	139	135	124	103	**142**	1562
Euston	45	71	78	91	93	120	**150**	91	**129**	**121**	110	90	92	1236
Goodooga	22	**212**	**168**	118	101	116	**162**	133	84	101	112	133	158	1598
Hungerford	39	**165**	118	**126**	79	80	105	64	70	53	87	105	**130**	1182
Ivanhoe	38	92	95	**108**	67	**107**	**119**	88	95	100	101	90	106	1168
Louth	41	**128**	**142**	125	69	115	97	73	87	67	87	112	**134**	1236
Menindie	43	57	79	64	61	**98**	**104**	58	86	68	80	82	**93**	930
Milparinka	40	**94**	55	70	59	65	**82**	46	45	43	63	66	**86**	774
Mossgiel	26	83	96	94	62	**119**	**134**	99	102	**108**	89	83	99	1168
Mount Hope	37	**147**	102	110	91	140	**150**	125	132	113	126	100	**151**	1487
Nymagee	38	**178**	132	139	122	135	**156**	128	133	120	129	110	**159**	1641
Pooncaira	40	71	75	70	68	**112**	**137**	75	**106**	91	92	81	80	1058
Tibooburra	33	72	**96**	82	49	45	**95**	50	47	48	64	76	**90**	814
Tilpa	40	**115**	80	82	77	**103**	100	68	75	66	81	84	**120**	1051
Wanaaring	38	**143**	**129**	98	66	97	86	53	67	58	75	113	**129**	1114
Wentworth	55	89	83	87	81	**131**	**129**	91	111	**120**	110	93	87	1212
White Cliffs	22	78	78	**80**	32	80	**88**	63	64	55	76	71	**130**	895
Wilcannia	44	92	82	94	68	**112**	**97**	60	80	73	**97**	66	82	1003
NORTH-WESTERN PLAINS							**District Av. 2256**							
Bellata	9	226	133	92	146	164	**236**	**235**	131	164	135	199	**357**	2218
Bogabilla	30	**302**	221	**268**	155	171	200	185	129	130	158	213	**289**	2421
Boomi	13	**311**	**244**	222	93	178	224	171	84	114	151	195	**320**	2307
Garah	16	**267**	**244**	240	114	179	209	146	115	104	142	173	**311**	2244
Millie	37	**263**	**250**	236	148	182	199	166	152	139	152	165	**255**	2307
Mogil	40	**218**	200	**206**	126	134	166	122	113	105	141	166	**224**	1921
Moree	43	**270**	**271**	**258**	129	176	201	147	139	146	188	193	229	2347
Mungindi	36	**233**	**270**	**236**	124	146	171	117	110	115	143	145	207	2017
Narrabri	52	**281**	**270**	258	163	198	240	186	168	164	189	218	**265**	2600
Pilliga	40	**237**	**196**	157	137	178	192	159	144	117	142	148	**213**	2020
Wee Waa	38	**284**	**235**	235	150	187	227	188	167	143	178	178	**254**	2426
CENTRAL WESTERN PLAINS							**District Av. 1821**							
Canonba	34	**215**	**189**	154	176	161	155	106	122	81	125	117	**199**	1800
Carinda	23	**157**	138	116	134	105	**146**	137	108	107	88	108	**216**	1560
Condoublin	42	**179**	127	144	131	140	**160**	128	152	124	139	116	**167**	1707
Coonamble	43	**199**	**204**	183	152	157	162	140	140	135	148	148	**184**	1952
Dandaloo	34	**214**	160	**188**	168	161	175	160	154	133	141	131	**188**	1973
Gilgandra	39	**236**	192	198	209	186	**214**	190	186	148	160	179	**241**	2339
Girlambone	35	**188**	**191**	135	149	135	141	103	106	89	110	112	**163**	1622
Gulargambone	34	**295**	210	220	159	203	**238**	169	177	127	151	175	**239**	2363
Lansdale	23	142	116	148	**152**	111	**155**	126	149	107	118	127	**164**	1615
Narromine	30	**187**	132	162	150	142	**200**	154	171	124	119	135	**174**	1850
Nevertire	34	**166**	**165**	134	154	143	152	131	130	101	105	136	**167**	1675
Nyngan	40	**193**	**186**	147	135	135	130	115	132	98	99	115	**172**	1657
Peak Hill	32	**235**	134	186	167	161	**195**	188	179	143	148	119	**194**	2049
Quambone	22	148	138	114	145	133	**162**	**151**	134	110	104	140	**189**	1668
Trangie	24	145	99	152	**165**	125	**168**	158	150	127	132	126	**177**	1724
Trundle	35	**172**	140	138	151	156	**178**	157	151	145	123	116	**175**	1802
Ungarie	30	**167**	90	120	119	133	**183**	143	142	141	139	106	**154**	1637
Walgett	44	**175**	127	141	150	117	144	139	120	146	146	**200**	**236**	1841
Warren	37	**186**	158	**160**	159	138	160	132	151	99	111	132	**188**	1774

AVERAGE MONTHLY AND ANNUAL RAINFALL AT SELECTED STATIONS IN NEW SOUTH WALES—*continued.*

Station.	No. of Years' Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
RIVERINA						**District Av. 1691**								
Ardlethan .	11	**196**	122	89	123	156	**203**	169	183	**188**	160	161	188	1938
Berrigan .	28	115	101	115	87	150	**212**	142	**172**	**164**	136	107	125	1626
Booligal .	32	80	56	96	77	**121**	**139**	100	**114**	95	102	101	81	1162
Cargelligo .	40	**143**	107	108	100	138	**150**	117	132	134	124	105	**155**	1513
Conargo .	28	83	93	196	87	**135**	**183**	111	**137**	133	107	199	91	1358
Coolamon .	35	145	131	163	151	162	**235**	**193**	173	169	**193**	134	136	1985
Corowa . .	40	135	132	150	132	193	**257**	197	**204**	**202**	185	146	145	2078
Culcairn .	11	87	113	145	112	207	**273**	**244**	**237**	225	204	135	208	2190
Currathool .	30	102	71	133	99	**139**	**191**	129	121	**132**	122	112	83	1434
Darlington Pt.	13	141	118	98	69	**145**	**201**	132	130	143	116	119	**148**	1560
Deniliquin .	63	100	108	136	134	**167**	**184**	128	143	**164**	151	113	89	1617
Griffith . .	8	103	85	48	90	131	**212**	148	**237**	**175**	165	107	152	1653
Grong Grong .	24	124	97	136	108	135	**209**	**163**	163	162	**164**	115	126	1702
Hay . .	42	83	97	103	109	**146**	**174**	119	**140**	130	118	99	99	1417
Henty . .	18	114	131	203	117	185	**273**	**232**	212	**233**	186	176	191	2253
Hillston .	36	113	97	102	86	**142**	**160**	120	133	122	**137**	110	100	1422
Howlong .	38	141	136	173	147	195	**292**	**225**	**228**	216	198	152	169	2272
Jerilderie .	34	100	86	102	108	**154**	**184**	130	**158**	137	131	122	100	1512
Leeton . .	8	106	75	75	107	134	**195**	146	**212**	**191**	170	106	187	1704
Maude . .	29	72	90	79	69	**127**	**150**	94	102	**109**	98	70	92	1152
Moama . .	44	76	119	127	115	**161**	**198**	138	**163**	159	160	105	96	1617
Moulamein .	35	65	85	95	97	**154**	**171**	105	**137**	135	112	110	109	1375
Narrandera .	42	134	111	137	132	151	**202**	141	**160**	150	**160**	120	106	1704
The Rock .	25	123	120	156	127	150	**260**	**214**	**204**	171	187	126	149	1987
Tocumwal .	25	100	83	120	92	167	**224**	154	**180**	**173**	138	108	112	1651
Urana . .	49	103	124	140	119	**180**	**217**	144	**155**	155	144	124	110	1715
Wagga . .	51	146	135	170	158	185	**262**	187	**197**	193	**204**	154	144	2135
Whitton .	35	126	103	**149**	116	137	**187**	**142**	139	132	142	113	119	1605
NORTH-WESTERN SLOPES								**District Av. 2727**						
Barraba .	42	**303**	257	233	177	157	212	165	155	186	239	**279**	**304**	2667
Bendemeer .	42	**364**	248	262	194	195	294	213	232	244	291	**308**	**363**	3211
Bingara .	43	**376**	**317**	297	184	223	236	204	199	201	265	262	**340**	3104
Blackville .	37	**291**	**254**	215	183	182	225	214	221	172	194	223	**313**	2687
Bogabri .	38	**220**	**226**	220	123	157	211	156	177	141	189	191	**266**	2277
Bundella .	10	253	**290**	256	149	138	189	136	164	131	173	**263**	**261**	2403
Gunnedah .	45	**240**	227	**236**	154	167	186	165	192	168	201	201	**274**	2411
Manilla . .	39	**328**	227	237	179	151	207	157	152	175	221	**254**	**305**	2593
Nundle . .	23	**306**	231	260	181	208	**331**	294	272	262	272	301	**389**	3307
Quirindi .	40	**286**	242	**245**	175	187	243	186	197	182	213	240	**355**	2751
Tamworth .	42	**283**	251	214	182	175	234	181	191	216	229	**265**	**296**	2717
Warialda .	44	**345**	**302**	285	163	190	220	178	177	195	215	229	**286**	2785
Werris Creek .	34	**286**	214	**235**	178	156	221	198	222	156	197	233	**300**	2596
Yetman . .	37	**331**	251	**264**	178	192	224	205	174	163	197	214	**274**	2670
SOUTH-WESTERN SLOPES								**District Av. 2434**						
Adelong .	40	215	140	230	188	246	**406**	**298**	**302**	270	268	189	207	2959
Albury . .	56	142	167	199	203	261	**344**	**287**	**289**	268	261	188	171	2780
Barmedman .	36	**161**	125	142	131	138	**202**	159	148	160	159	127	**168**	1820
Burrowa .	41	190	127	180	172	165	**245**	**203**	**205**	185	197	148	199	2216
Cootamundry .	34	183	126	178	188	181	**274**	**221**	**216**	199	208	157	180	2311
Grenfell .	37	203	164	186	177	182	**270**	**229**	220	204	194	150	**233**	2412
Gundagai .	30	158	102	194	194	194	**306**	**244**	**240**	217	228	147	200	2424
Holbrook .	38	167	151	199	185	237	**374**	**297**	**273**	253	234	197	208	2775
Junee . .	40	144	127	163	149	170	**238**	181	188	**192**	**195**	149	158	2054
Koorawatha .	19	149	155	151	142	140	**220**	**228**	190	199	178	123	**255**	2130
Marsden .	41	**198**	133	162	152	152	**205**	163	161	163	171	127	**194**	1981
Morangarell .	38	**221**	121	161	156	160	**210**	181	178	169	165	153	**203**	2078
Murrumburrah	38	215	131	194	196	163	**266**	**223**	**221**	204	188	156	218	2375
Temora . .	43	164	109	147	139	159	**224**	174	176	176	**192**	162	**178**	2000
Tumbarumba .	38	251	209	290	244	321	**516**	**423**	**396**	384	366	249	312	3961
Tumut . .	37	216	141	237	220	249	**415**	**326**	**317**	286	276	192	233	3108
Tarcutta .	51	183	135	198	180	222	**316**	242	**248**	225	**245**	196	174	2564
W. Wyalong .	18	**170**	125	150	106	140	**200**	143	152	152	135	128	**184**	1785
Young . .	51	191	154	185	190	200	**298**	**238**	**232**	221	220	165	210	2504

AVERAGE MONTHLY AND ANNUAL RAINFALL AT SELECTED STATIONS IN NEW SOUTH WALES—*continued.*

Station.	No. of Years' Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
CENTRAL WESTERN SLOPES							**District Av. 2380**							
Coolah . .	38	**279**	**239**	230	165	179	239	225	207	189	193	207	**282**	2631
Coonabarrabran	43	**285**	**303**	222	230	231	255	230	224	194	195	197	**264**	2830
Cudal . .	38	**261**	149	184	178	190	**247**	213	215	200	192	183	**250**	2162
Dubbo . .	50	**209**	167	186	175	185	**202**	167	177	173	158	178	**220**	2197
Dunedoo .	11	201	117	150	157	192	**239**	**268**	156	153	122	158	**273**	2186
Forbes . .	47	171	151	154	158	166	**188**	156	**176**	173	170	129	**177**	1969
Molong . .	38	**259**	170	230	214	219	**291**	234	258	219	220	194	**284**	2792
Parkes . .	33	**213**	129	179	151	164	**217**	181	191	167	157	127	**196**	2072
Wellington .	41	**202**	151	176	166	190	**226**	182	201	169	180	189	**250**	2282
NORTHERN TABLELANDS							**District Av. 3287**							
Armidale .	57	**364**	**335**	278	196	175	268	204	184	215	265	324	**357**	3165
Bundarra .	37	**377**	245	**295**	190	170	229	174	197	209	272	279	**372**	3009
Drake . .	31	**520**	**525**	**493**	296	242	228	217	135	199	266	346	424	3891
Deepwater .	33	**415**	283	**292**	145	176	252	223	186	211	258	274	**364**	3079
Emmaville .	38	**414**	293	304	160	190	278	232	208	238	296	**329**	**381**	3323
Glen Innes .	41	**427**	294	291	161	176	241	192	192	207	294	**301**	**386**	3162
Guyra . .	32	**400**	330	**332**	204	207	288	255	231	233	303	321	**432**	3539
Inverell . .	48	**373**	278	**289**	189	205	233	205	192	209	256	265	**334**	3028
Tabulam .	32	**491**	**515**	**519**	237	207	201	181	127	201	281	324	396	3680
Tenterfield .	52	**422**	313	**316**	171	179	223	231	179	232	263	315	**379**	3223
Uralla . .	38	**388**	283	267	183	178	297	218	217	234	267	**309**	**367**	3208
Walcha . .	43	**343**	287	274	185	181	273	204	204	232	266	**326**	**366**	3114
CENTRAL TABLELANDS							**District Av. 3323**							
Bathurst .	64	**247**	**216**	196	162	179	199	177	175	177	216	215	**229**	2388
Blackheath .	27	**432**	396	373	325	371	331	**432**	267	249	277	283	**462**	4198
Blayney .	37	281	167	210	182	206	**331**	**297**	**302**	246	256	191	269	2938
Carcoar . .	42	261	165	197	188	207	**374**	**298**	**301**	260	275	220	248	2994
Cassilis . .	51	**252**	**233**	208	145	172	197	174	174	175	171	196	**241**	2338
Cowra . .	37	**231**	146	187	182	163	**245**	198	202	199	208	144	**253**	2358
Gulgong .	42	**247**	201	217	183	187	**243**	190	186	187	202	213	**280**	2536
Hill End .	41	241	184	226	210	234	**331**	235	262	234	**280**	242	**279**	2958
Katoomba .	37	**646**	**622**	**651**	434	421	430	484	348	295	317	372	541	5561
Kurrajong .	55	**577**	**604**	**615**	438	430	313	307	235	278	308	411	493	5009
Lawson . .	27	**518**	487	444	375	393	316	**496**	318	267	293	337	**521**	4765
Lithgow .	33	**352**	280	**327**	229	244	317	**355**	242	224	246	219	315	3350
Mt. Victoria .	51	**371**	**418**	**370**	279	295	306	331	228	226	246	276	344	3690
Mudgee . .	48	**219**	216	184	175	199	**263**	197	202	218	211	195	**277**	2556
Orange . .	51	268	243	257	212	289	**436**	**329**	**347**	293	298	255	279	3506
Rockley .	27	**265**	165	220	154	204	**246**	229	235	197	217	180	**238**	2550
Rylstone .	38	**254**	205	201	183	173	**246**	201	190	196	189	198	**318**	2554
Springwood .	36	**426**	412	**510**	340	331	269	297	215	236	250	341	**424**	4051
Taralga . .	38	**287**	200	246	209	195	**308**	**292**	233	226	210	195	244	2845
SOUTHERN TABLELANDS							**District Av. 2843**							
Adaminaby .	34	254	194	232	162	175	**301**	245	207	**276**	256	198	**265**	2765
Araluen .	31	**379**	**324**	323	231	232	279	**335**	228	245	251	182	295	3304
Bombala .	38	**254**	195	220	140	140	**232**	197	153	181	193	176	**265**	2346
Braidwood .	45	**285**	**263**	243	215	208	241	227	186	186	225	206	**257**	2742
Bungendore .	33	**253**	157	195	160	148	**226**	205	178	195	**207**	164	203	2291
Canberra .	9	154	156	**244**	138	125	**227**	205	202	210	188	152	**236**	2237
Cooma . .	58	**217**	**202**	**191**	125	121	143	130	88	162	170	176	182	1907
Crookwell .	39	274	164	251	208	223	**400**	**347**	**331**	287	270	198	266	3219
Delegete .	33	**243**	218	243	173	173	**244**	210	173	203	231	183	**253**	2547
Goulburn .	58	**266**	**226**	216	172	183	198	181	183	206	216	202	**237**	2486
Gunning .	37	**248**	152	206	176	166	**253**	224	229	227	207	178	**230**	2496
Jindabyne .	18	**224**	133	206	109	153	183	152	140	**228**	162	159	**239**	2088
Kiandra .	48	410	307	401	413	551	**875**	**654**	595	**682**	652	460	424	6424
Kosciusko .	12	452	315	358	261	340	405	**501**	368	**537**	483	291	**544**	4855
Michelago .	37	**260**	164	**204**	154	143	198	157	136	177	189	151	**229**	2162
Nimmitabel .	28	**312**	229	230	141	175	241	**302**	197	211	206	142	**267**	2653
Queanbeyan .	52	**227**	173	**209**	158	161	194	154	157	191	**213**	206	208	2251
Yass . .	40	**231**	127	185	169	162	**273**	**226**	226	202	215	177	205	2398

AVERAGE MONTHLY AND ANNUAL RAINFALL AT SELECTED STATIONS IN NEW SOUTH WALES—*continued.*

Station.	No. of Years' Records.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
NORTH COAST					District Av. 5445									
Ballina	28	598	**711**	**616**	598	**802**	550	591	392	325	293	355	462	6293
Bellingen	23	**632**	**649**	**726**	521	541	349	341	199	270	365	419	484	5526
Byron Bay	30	828	**915**	**947**	671	**844**	626	570	449	377	400	487	627	7741
Casino	49	**513**	**584**	**581**	389	315	248	258	197	222	279	354	392	4332
Clarence Heads	46	542	580	**661**	**571**	**636**	448	459	339	298	300	311	410	5555
Coff's Harbour	22	554	**667**	**760**	654	**663**	429	382	248	288	419	438	477	5979
Grafton	28	**441**	**415**	**403**	266	301	213	240	131	200	222	301	393	3526
Kempsey	40	**468**	**531**	**512**	365	400	340	320	275	251	287	314	404	4467
Kyogle	9	**556**	**523**	451	289	407	155	255	131	307	230	343	**514**	4161
Lismore	39	**568**	**688**	**715**	444	465	317	364	246	271	248	351	419	5096
Maclean	32	**483**	**526**	**624**	414	436	318	363	227	238	246	341	379	4595
Mullumbimby	24	646	**656**	**876**	604	**704**	432	474	309	317	336	349	479	6182
Murwillumbah	29	**999**	**912**	**986**	533	576	410	379	253	315	350	429	550	6692
Nambucca Hds.	18	488	**627**	**673**	512	**552**	267	251	244	284	279	360	377	4914
Tweed Heads	36	**798**	**832**	**1015**	645	624	423	424	308	354	335	382	481	6621
HASTINGS, HUNTER and MANNING							District Av. 3992							
Bullahdelah	18	432	487	496	449	**634**	343	**504**	287	387	293	268	**518**	5098
Clarencetown	27	345	359	376	349	**385**	332	**421**	310	308	300	257	**425**	4167
Denman	40	**256**	197	**215**	156	151	163	178	144	162	150	193	**247**	2212
Dungog	24	303	**363**	327	313	319	259	**365**	268	284	255	247	**389**	3692
Forster	26	376	352	442	**465**	**556**	367	**493**	332	334	262	269	418	4666
Gloucester	33	**406**	395	**480**	301	303	253	265	220	246	264	334	**464**	3931
Gosford	41	416	484	**551**	459	**512**	356	**501**	334	367	301	312	371	4964
Gresford	27	**332**	**322**	312	255	261	278	280	217	230	227	246	**353**	3313
Jerry's Plains	37	**285**	233	**245**	167	167	190	219	135	169	184	222	**280**	2496
Laurieton	38	**571**	**639**	**630**	529	545	408	444	382	371	313	382	499	5713
Maitland	55	**333**	**332**	**375**	287	278	250	292	213	265	227	234	311	3397
Manning Heads	36	499	**576**	**568**	475	**547**	421	448	374	369	315	391	193	5176
Merriwa	41	**256**	207	**210**	150	145	175	178	159	165	154	186	**255**	2240
Murrurundi	51	**297**	276	245	212	207	**308**	249	259	229	243	253	**330**	3108
Muswellbrook	52	**241**	**228**	213	162	175	206	199	162	165	174	200	**247**	2372
Newcastle	58	360	426	**485**	443	**501**	374	**478**	326	331	296	263	339	4622
Paterson	19	340	407	**424**	380	344	243	**436**	177	326	297	235	**445**	4054
Port Macquarie	61	571	**709**	**625**	593	**612**	445	442	362	402	336	373	531	6006
Raymond Terr.	25	332	324	384	**418**	377	275	**444**	307	333	286	229	**391**	4100
Scone	46	**268**	**251**	215	160	157	177	179	177	169	171	197	**278**	2399
Seal Rocks	25	412	349	**496**	471	**676**	416	**761**	427	455	343	290	366	5462
Singleton	40	280	**281**	**317**	220	193	224	252	159	192	204	239	**288**	2849
Stroud	33	416	**503**	**548**	384	370	352	405	309	300	304	286	**431**	4608
Taree	39	**448**	**579**	**486**	420	395	315	360	272	280	263	295	443	4556
Wyong	36	421	386	**520**	**439**	424	409	**441**	279	302	264	299	413	4597
METROPOLITAN					District Av. 3767									
Parramatta	56	356	**368**	**411**	308	294	291	**359**	220	215	237	239	295	3593
Penrith	26	**283**	244	280	250	244	186	**345**	183	165	209	231	**337**	2957
Riverview	18	394	326	**436**	407	**437**	278	**516**	216	266	273	215	398	4162
Sydney	64	366	442	**497**	**533**	**514**	484	497	301	292	296	284	285	4791
Undercliffe	8	369	299	237	**558**	**478**	163	**485**	157	324	332	271	420	4093
Windsor	59	**304**	**322**	**334**	252	278	258	244	145	185	200	226	257	3005
SOUTH COAST					District Av. 3946									
Bateman's Bay	27	**410**	327	350	311	339	357	**359**	248	270	216	207	**357**	3751
Bega	40	**373**	**352**	**389**	219	244	335	267	210	228	249	198	313	3377
Bodalla	47	**405**	**393**	**419**	277	267	298	269	209	292	275	256	291	3651
Bowral	38	**389**	286	**414**	288	293	351	**400**	249	223	234	244	360	3731
Camden	38	**334**	218	**322**	239	218	238	296	173	155	187	204	**310**	2894
Candelo	35	**304**	**316**	**336**	171	205	284	214	174	216	215	176	270	2881
Crookhaven	18	405	376	**425**	372	**468**	345	**484**	243	286	244	270	419	4337
Eden	51	**343**	318	**335**	277	324	**330**	249	219	250	268	243	260	3416
Gabo Island	58	270	284	292	310	**418**	**444**	**339**	299	324	323	262	236	3801
Jervis Bay	56	433	449	520	**644**	**654**	**543**	525	365	381	339	311	339	5503
Kiama	37	**485**	442	**611**	481	446	443	**521**	313	324	273	312	448	5099
Milton	38	423	437	447	**481**	**475**	361	**483**	253	307	367	321	380	4735
Moruya Heads	47	**378**	**331**	**404**	308	277	303	260	199	279	268	232	266	3505
Moss Vale	50	**383**	334	**370**	311	335	357	**406**	249	243	291	253	310	3842
Nowra	39	**439**	303	**420**	315	334	393	**396**	229	225	250	231	336	3871
Panbula	13	**474**	268	**377**	209	223	246	295	127	280	202	212	**329**	3272
Picton	43	**340**	257	**349**	287	225	228	269	171	189	230	210	**308**	3063
Robertson	33	**617**	498	**724**	492	485	617	**717**	430	390	358	304	489	6121
Sutton Forest	19	**380**	195	356	259	253	284	**476**	195	206	300	187	**378**	3469
Wollongong	49	455	**469**	**458**	**496**	455	406	413	243	281	288	287	360	4611

APPENDIX IV

QUEENSLAND RAINFALL

The Queensland average monthly and annual rainfalls given in Appendix IV cover periods ranging from 20 to 50 years, and have been supplied by courtesy of Mr. H. A. Hunt, Commonwealth Meteorologist.

The values shown embrace records up to, and inclusive of, 1922, and may be taken as well-established normals, in all but the far inland districts of scanty and erratic rainfall.

QUEENSLAND AVERAGE MONTHLY AND ANNUAL RAINFALLS TO END OF 1922.

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
PENINSULA, NORTH													
Cape York	1464	1399	1502	919	260	103	73	35	23	51	185	728	6,745
Coen	1182	1076	947	443	65	40	27	12	4	64	220	612	4,722
Mein	1326	1061	898	307	60	34	12	11	5	59	249	734	4,756
McDonnell	1826	1495	1211	552	145	63	48	41	19	62	289	823	6,574
Moreton	1309	1167	999	373	97	36	28	12	19	67	294	809	5,210
Thursday Island	1780	1626	1402	783	184	46	36	21	10	30	132	723	6,773
PENINSULA, SOUTH													
Fairview	1137	856	733	198	34	37	15	5	21	59	195	569	3,859
Musgrave	1155	1048	896	309	64	31	15	10	8	58	223	659	4,476
Palmerville	1106	990	758	242	64	41	22	10	39	87	228	673	4,260
Walsh River	767	714	612	153	52	37	23	1	10	70	146	614	3,229
LOWER CARPENTARIA													
Burketown	845	639	506	109	14	21	5	3	4	49	163	466	2,815
Cloncurry	484	466	252	81	40	49	41	15	37	42	132	325	1,964
Croydon	884	668	434	103	46	31	14	11	21	57	176	471	2,916
Donors Hill	825	594	418	117	37	52	17	13	15	73	162	414	2,737
Gilbert River	904	811	504	150	43	34	23	11	21	76	167	557	3,301
Granada	770	555	285	107	51	41	25	5	22	53	151	325	2,390
Mackinlay	426	387	258	88	53	59	46	9	32	45	117	244	1,764
Normanton	1179	1010	590	166	41	33	16	8	10	47	192	612	3,934
UPPER CARPENTARIA													
Georgetown	840	802	509	135	46	41	30	17	29	72	183	601	3,305
Hughenden	538	362	239	135	68	91	49	33	44	85	135	324	2,103
Mt. Surprise	795	746	459	162	74	65	28	19	18	83	181	521	3,142
Pentland	722	441	390	165	74	132	58	56	68	89	124	377	2,696
Richmond	511	368	223	84	55	75	31	11	29	64	135	274	1,863
NORTH COAST (Barron)													
Cairns	1668	1521	1804	1219	473	286	163	178	169	200	403	902	8,986
Cooktown	1501	1332	1509	921	314	203	99	137	58	113	271	698	7,156
Herberton	966	752	834	436	178	101	73	68	48	96	233	569	4,354
NORTH COAST (Herbert)													
Cardwell	1695	1708	1627	974	378	206	147	132	145	208	408	844	8,472
Clarke River	688	468	407	136	82	72	47	44	52	68	136	366	2,566
Ingham	1630	1592	1608	886	370	243	166	140	129	169	373	716	8,022
Innisfail	2060	2205	2586	2162	1300	710	474	528	365	304	624	1205	14,523
Townsville	1166	1164	776	383	141	125	60	47	79	129	181	555	4,806

QUEENSLAND AVERAGE MONTHLY AND ANNUAL RAINFALLS TO END OF 1922—*cont.*

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
CENTRAL COAST, EAST													
Ayr . . .	1209	883	720	286	126	128	72	54	152	102	177	391	4,300
Bowen . .	1037	864	592	290	138	158	98	71	83	106	129	448	4,014
Mackay . .	1513	1153	1242	678	396	268	176	106	163	187	289	687	6,858
Marlborough .	751	691	483	206	173	222	119	96	119	188	270	496	3,814
Nebo . . .	670	484	454	192	136	173	127	75	121	101	202	377	3,112
Ravenswood .	774	507	436	153	97	129	59	57	81	82	167	322	2,864
St. Lawrence .	1004	801	597	280	191	244	131	91	133	184	231	462	4,349
CENTRAL COAST, WEST													
Charters Towers .	577	439	377	176	84	130	67	53	79	71	154	363	2,570
Mt. McConnell .	584	362	354	95	87	90	51	50	78	69	149	373	2,342
CENTRAL HIGHLANDS													
Alpha . . .	407	365	267	160	113	162	107	80	90	142	173	244	2,310
Blackall . .	304	362	267	155	163	131	115	64	84	140	145	271	2,201
Clermont . .	527	417	326	176	138	167	106	76	104	145	203	382	2,797
Dingo . . .	583	416	344	126	94	156	109	89	117	159	209	345	2,747
Emerald . .	476	365	298	147	120	175	108	102	119	156	177	333	2,576
Rolleston . .	437	357	280	153	152	197	141	112	130	165	224	281	2,629
Springsure . .	424	406	305	151	136	178	115	110	128	169	199	300	2,621
Tambo . .	315	327	273	146	160	134	120	78	97	147	164	256	2,217
Taroom . .	432	312	278	143	163	184	150	131	145	168	286	285	2,677
CENTRAL LOWLANDS													
Aramac . .	321	319	252	144	106	120	90	43	69	104	128	191	1,887
Barcaldine . .	356	314	272	164	135	118	103	56	76	121	135	238	2,088
Isisford . .	274	319	253	153	115	104	86	44	63	92	126	184	1,813
Jericho . .	379	303	278	125	75	159	96	74	82	145	181	312	2,209
Lochnagar . .	370	283	250	124	109	118	106	52	110	121	165	327	2,135
Longreach . .	243	402	236	98	101	85	84	31	53	92	115	191	1,731
Muttaburra . .	376	328	258	140	94	100	80	32	63	80	122	177	1,850
Tangorin . .	408	328	201	97	51	95	67	22	26	87	102	199	1,683
Twin Hills . .	570	427	275	123	96	181	75	85	102	110	165	282	2,491
UPPER WESTERN													
Ayrshire Downs .	402	348	208	75	73	63	64	20	42	67	114	228	1,704
Camooweal . .	416	354	212	48	25	39	33	20	26	53	114	229	1,599
Kynuna . .	368	322	203	69	51	65	51	13	39	60	144	290	1,675
Lake Nash . .	367	299	237	42	40	36	36	22	31	53	65	191	1,419
Urandangie . .	237	275	176	61	41	37	41	18	26	33	81	157	1,186
West Leichhardt .	409	371	181	64	34	43	43	11	34	75	164	249	1,678
Winton . .	344	303	209	61	59	64	67	20	40	63	126	176	1,532
LOWER WESTERN													
Boulia . . .	209	198	172	78	44	51	35	25	34	53	111	155	1,165
Jundah . .	230	275	229	107	85	92	78	41	64	95	86	181	1,563
Windorah . .	160	187	188	112	81	81	65	49	41	69	96	151	1,283
DARLING DOWNS, EAST													
Cambooya . .	400	295	306	160	170	186	171	146	184	237	292	376	2,923
Chinchilla . .	392	268	298	139	150	197	151	122	130	215	250	312	2,624
Dalby . . .	332	286	272	124	136	170	182	124	177	209	262	307	2,581
Goondiwindi .	309	268	281	156	188	189	183	129	163	178	209	285	2,538
Inglewood . .	338	280	280	125	194	200	192	130	179	207	254	293	2,672
Pittsworth . .	377	314	336	144	159	184	182	126	181	230	269	338	2,840
Killarney . .	361	326	325	171	151	181	189	137	198	221	271	330	2,861
Stanthorpe . .	350	328	276	169	197	188	208	185	216	261	272	353	3,033
Texas . . .	356	268	242	150	169	203	191	140	175	199	235	316	2,644
Toowoomba .	490	432	389	246	231	235	209	177	225	264	323	419	3,640
Wallangarra .	358	278	261	139	166	202	212	148	207	232	275	328	2,806
Warwick . .	317	309	266	164	163	180	185	156	190	235	255	351	2,801

QUEENSLAND AVERAGE MONTHLY AND ANNUAL RAINFALLS TO END OF 1922—*cont.*

DARLING DOWNS, WEST

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Dulacca . .	398	246	268	126	130	189	157	92	123	197	204	224	2,354
Miles . . .	385	264	273	138	157	192	178	121	146	198	243	258	2,553
Talwood . .	217	223	143	74	185	190	184	66	111	109	189	284	1,975

SOUTH COAST. Pt. Curtis

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Bundaberg . .	917	613	544	288	276	269	195	140	177	210	254	473	4,356
Camboon . .	417	342	263	149	146	212	157	125	153	209	254	350	2,777
Childers . .	788	585	502	246	235	220	171	133	195	240	278	542	4,135
Eidsvold . .	424	350	315	141	159	196	126	131	155	220	239	369	2,855
Gayndah . .	477	404	327	130	160	187	152	125	157	238	280	393	3,030
Gladstone . .	781	675	520	242	197	244	161	98	138	181	265	505	4,010
Hawkwood . .	437	306	309	128	174	190	158	127	159	180	258	385	2,811
Miriam Vale .	996	766	527	290	221	269	158	131	161	224	265	588	4,596
Mt. Morgan . .	623	475	363	139	139	193	128	112	119	186	243	406	3,126
Mt. Perry . .	754	547	470	203	204	248	180	132	147	231	263	456	3,835
Rockhampton .	796	760	487	223	173	234	163	90	135	187	229	469	3,946
Rosedale . .	1060	599	520	268	189	254	171	151	167	251	253	515	4,398
Sandy Cape . .	696	622	690	464	460	425	311	251	267	195	241	374	4,996
Westwood . .	552	465	304	183	152	220	135	110	120	171	231	369	3,012

SOUTH COAST. Moreton

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Boonah . .	462	323	416	184	145	221	152	139	187	223	346	487	3,285
Brisbane . .	642	635	584	359	288	264	231	214	210	262	366	496	4,551
Dunwich . .	906	820	828	558	653	469	395	249	276	280	387	533	6,354
Esk . . .	554	539	483	262	211	203	203	159	232	250	313	440	3,849
Gympie . .	673	661	626	309	305	252	218	185	218	272	314	574	4,607
Ipswich . .	490	460	426	247	204	203	171	149	193	240	302	346	3,431
Kilkivan . .	568	495	403	206	196	205	171	158	175	261	258	427	3,523
Maryborough .	742	647	630	331	313	285	196	173	198	269	309	469	4,562
Nanango . .	452	422	337	183	164	204	179	145	193	229	256	374	3,138
Sandgate . .	673	712	666	325	287	246	232	166	214	242	408	487	4,658
Southport . .	702	683	805	475	521	320	322	212	289	287	348	487	5,451
St. Helena . .	598	667	626	357	341	317	240	165	219	263	321	457	4,571
Tallebudgera .	739	660	808	572	671	334	388	241	322	297	439	512	5,983
Tewantin . .	862	867	984	684	658	436	303	211	312	335	384	543	6,579
Woodford . .	736	875	813	415	300	266	252	186	223	259	319	539	5,183
Yandina . .	965	1127	956	480	489	365	264	207	238	323	365	659	6,438

MARANOA

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Mitchell . .	319	334	305	137	145	183	151	100	137	141	193	274	2,419
Roma . . .	340	305	281	126	147	172	151	97	155	178	201	240	2,393
St. George . .	281	262	223	142	158	166	136	100	121	136	153	195	2,073
Surat . . .	284	339	273	117	135	196	184	108	135	186	152	271	2,380
Yeulba . .	369	305	314	125	150	191	185	109	133	188	248	249	2,566

WARREGO

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Augathella . .	324	301	290	156	147	180	127	75	114	149	154	261	2,278
Bollon . .	227	207	191	120	130	157	116	97	108	133	145	213	1,844
Charleville . .	240	301	244	149	142	139	131	77	81	130	155	239	2,028
Cunnamulla . .	124	226	152	119	116	122	93	81	85	95	100	157	1,470
Dirranbandi . .	245	211	203	131	142	166	119	92	108	128	126	212	1,883
Eulo . . .	135	172	135	76	85	116	82	81	61	82	97	130	1,252
Hebel . . .	147	180	149	106	107	138	135	87	86	119	137	183	1,574
Wyandra . .	130	225	117	88	79	129	136	66	106	85	102	170	1,463
Morven . .	286	288	277	130	153	165	125	85	117	139	162	270	2,197

FAR SOUTH-WEST

District.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Adavale . .	266	246	208	106	108	129	98	54	66	99	122	176	1,678
Thargomindah .	148	167	80	74	83	84	53	57	54	82	97	112	1,121

BOOKS OF REFERENCE ON COTTON

Frequently one of the most tantalising obstacles confronting students of cotton is the difficulty experienced in ascertaining the names of books relating thereto, their authors and the address of their publishers. The word 'Cotton' embraces such a gigantic subject that the name of a book may not always be an index to that branch of the industry with which it deals, and for this reason a very brief résumé is here given of each work, so that those who wish to go deeper into the subject may know what books to order, and may be saved the disappointment of purchasing a book which primarily deals with a section of the cotton industry in which they are not interested.

Although the following list does not by any means attempt to give the names of all authors and books, it is hoped that it may be of some use to those who wish to obtain a deeper, truer knowledge of cotton in all its branches.

Cotton (Common Commodities and Industries). By R. J. Peake. Published by Sir Isaac Pitman & Son, Ltd., 1 Amen Corner, London, E.C. 4. This book deals concisely and in a broad way with cotton spinning and manufacture.

Official Report of the International Federation of Master Cotton Spinners and Manufacturers to Egypt, 1912. By Arno Schmidt. Printed by Taylor, Garnett, Evans & Co., Ltd., Manchester, England. Price 21*s*. An official report on cotton growing in Egypt and the Anglo-Egyptian Soudan. This book also contains much valuable general information on local conditions in Egypt and the Soudan, the handling, ginning and transportation of cotton in those countries, together with the methods of land reclamation.

The Development and Properties of Raw Cotton. By W. L. Balls, M.A. Published by Macmillan & Co., London. A most valuable and authoritative work, dealing in detail with the habits, growth and properties of the cotton plant in Egypt.

The Cotton Plant in Egypt. Studies in Physiology and Genetics. By W. L. Balls, M.A. Published by Macmillan & Co., London. A scientific, botanical work treating of the properties of the cotton plant.

Mendelism. By R. C. Punnett, F.R.S. Published by Macmillan & Co., London. Deals with Gregor Mendel's theories and laws.

Mendel's Principles of Heredity. By W. Bateson, M.A. Cambridge University Press, England. Expounds Mendel's law with relation to both plants and animals.

Hindi Cotton in Egypt. By O. F. Cook, U.S. Department of Agriculture, Washington, U.S.A. A treatise on the effects of natural crossing, hybrids, etc.

The Story of the Cotton Plant. By Frederick Wilkinson, F.R.S. Published by D. Appleton & Co., London and New York, 1912. This book gives a brief account of cotton growing in various countries and of the processes entailed in the manufacture of cotton.

Cotton Facts. By Alfred B. Shepperson. Shepperson Publishing Co., Cotton Exchange Building, New York. A compilation from official and reliable sources of crops, receipts, stocks, exports, consumption and manufacturing output ; published annually.

Cotton. By George Bigwood. Published by Henry Holt & Co., New York, 1919. Treats largely of the history of cotton manufacturing, machinery and merchandise, together with a most interesting Appendix on cotton ' Futures.'

Cotton and Other Vegetable Fibres. By Goulding-Dunstan. Published by D. Van Nostrand & Co., 8 Warren Street, New York, 1919. Embraces cotton growing in various countries and parts of the British Empire, also flax, hemp, ramie, jute and similar fibres, cordage fibres, miscellaneous fibres.

Wild and Cultivated Cotton Plants of the World. By George Watt. Published by Longmans, Green & Co., 39 Paternoster Row, London, 1907. Treats of the different species and sub-varieties of cotton plants.

The World's Cotton Crops. By John A. Todd. Published by A. & C. Black, Soho Square, London, 1923. Price 12*s.* 6*d.* This work gives details of cotton production in various countries of the world, is well illustrated and, in addition to containing diagrams of areas producing cotton, includes numerous statistical tables of the world's production, consumption and spinners' takings.

Climate and Weather of Australia. By H. A. Hunt, G. Taylor, and E. T. Quayle. Published in 1913 by A. J. Mullett, Government Printer, Melbourne. Price 5*s.* A semi-official work, dealing exclusively with the meteorology of Australia, rainfall, climate and temperatures of the various States.

Official Year Book of N.S.W., 1921. Published by J. Spence, Acting Government Printer, in 1922, under authority of the N.S.W. Government. Price 5*s.* This annual publication of the N.S.W. Government is an official record of vital statistics, agriculture, climate, commerce, etc., of the State of N.S.W.

Cotton Growing Within the British Empire. By J. W. McConnel, Chairman of the Fine Spinners and Doublers Association, 1921. Printed in Great Britain by Billing & Sons, Ltd., Guildford and Esher. A paper read before the Royal Colonial Institute which deals with the world's capacity for consuming cotton goods, together with cotton growing in various British possessions.

Cooksland. By John Dunmore Lang, D.D., M.A. Published by Longman, Brown, Green & Longmans, Paternoster Row, London, 1847. One of the earliest books written on Australia. The area dealt with, 'Cooksland,' now roughly comprises the southern district of Queensland and the northern district of New South Wales. Some interesting references to early Australian cotton-growing experiments are made in this book.

Queensland. By John Dunmore Lang, D.D., M.A. Published by Edward Stanford, 6 Charing Cross, London, 1861. This is to a great extent a reprint of Dr. Lang's book, 'Cooksland,' published in 1847, but contains a few additional details of cotton growing in Australia at that date.

Queensland. By George Wight. Published in 1863 by G. Street, Esq., Colonial Newspaper Offices, 30 Cornhill, London, E.C. A work on Queensland containing a few reliable facts with reference to early attempts at cotton growing in that State.

Buyers and Sellers in the Cotton Trade. By H. B. Heylin. Published by Charles Griffin & Co., Ltd., London, 1913. This work is a handbook for merchants, shippers, and manufacturers, dealing almost entirely with technicalities connected with the trade, and will therefore be of small interest to the grower.

The Soils of New South Wales. By H. I. Jensen, D.Sc. Published by Department of Agriculture, N.S.W., Sydney, 1914. Price 5*s*. A scientific work dealing in detail with the chemical analyses and mechanical analyses of the soils of New South Wales.

Rainfall Observations made in Queensland, 1860–1913; Rainfall Observations made in New South Wales, 1909–1914; Rainfall Observations made in Victoria, 1840–1910; Rainfall Observations made in South Australia and the Northern Territory, 1870–1917. Official Government publications issued by H. A. Hunt, Commonwealth Meteorologist, and printed by the Government Printer, Melbourne. Prices, 10*s*. 6*d*., 10*s*. 6*d*., 4*s*. 6*d*., and 10*s*. 6*d*. respectively. A collection of meteorological facts and figures relating to climate, temperatures and rainfall of Australian States.

Indian Cotton. A report, by Arno S. Pearse, on cotton growing in India. Issued by the International Federation of Master Cotton Spinners and Manufacturers' Association, Manchester, in 1915. Price 5*s*.

Handbook of Spinning Tests for Cotton Growers. By W. Lawrence Balls, M.A. Published by Macmillan & Co., Ltd., St. Martins Street, London, 1920. The treatment of cotton fibre in a spinning mill.

Soils. By E. W. Hilgard, Ph.D., LL.D. Published by Macmillan & Co., Ltd., St. Martins Street, London, 1907. A work dealing with the formation, properties and composition of soils,

together with relation to climate and plant growth in the humid and arid regions of America.

Official Year Book of the Commonwealth of Australia. Published by Commonwealth Bureau of Census and Statistics, 1922. Printed by the Government Printer, Melbourne. Price 4*s*.

The Farmer's Handbook, 1922. Issued by New South Wales Department of Agriculture. Printed by the Government Printer, Sydney. Price 10*s*. 6*d*. A text-book relating to farming in general, containing the methods recommended for the cultivation of various crops in the State of New South Wales.

Elementary Lessons on the Chemistry of the Farm, Dairy, and Household. By J. C. Brünnich, F.I.C., Chemist to the Department of Agriculture and Stock, Brisbane. Published by the Government Printer, William Street, Brisbane, Queensland. Second Edition, 1923.

Report on Cotton-growing Possibilities in Western Australia, and Report on Cotton-growing Possibilities in the Northern Territory. By G. Evans. Published respectively under the authority of the Hon. Minister for the North-West, Perth, Western Australia, and under the authority of the Right Hon. the Minister for Home and Territories, Melbourne.

INDEX

Printed in England at THE BALLANTYNE PRESS
SPOTTISWOODE, BALLANTYNE & CO. LTD.
Colchester, London & Eton